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Fruitful Industrial Research in Electronics

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Industrial research in any area should be directed primarily towards realizing immediate economic gains. The conditions of the market for particular products on the one hand and technological factors on the other come into the picture only to the extent necessitated by economics. Electronics in India is in such a rudimentary stage, compared to its full potentialities, that an elaborate analysis is not required to find fruitful areas for industrial research. The immediate objectives can be limited to the design and development of equipment of the kind already in use in the advanced countries. The applications of simple electronic equipment to many aspects of the day to day life of the common man as well as to the increased production of better quality goods in almost every industry is well known abroad and should dominate industrial research in electronics in India in the coming decade.

Tasks

In a young but complex technology such as electronics, what does a country like India, which is just making a beginning, see especially when the aim is to take up tasks with clear-cut objectives and commitments? The picture is one of many special problems and ideas whose inter-relations are not well understood. It is precisely this situation that calls for a predominantly technical bias in deciding on the tasks of industrial research. In other words, guided by well defined and specific economic objectives, equally well defined and specific technical tasks should be set forth. This will create a broad and clearly defined and limited field where entrepreneurs, designers and inventors alike will be able to make their maximum contribution.

Illustrations

It is only necessary to cite a few examples of electronic equipment, components and primary materials in order to complete the present discussion and, as it were, set the ball rolling in the field. These are dealt with in the following paragraphs.

General purpose electronic test instruments

Cathode ray oscilloscopes, signal generators, vacuum tube voltmeters, insulation testers and *p*H meters are but a few items in this category. The market for instruments is characterized by the following:

(i) The demand is widely scattered in location and, say, in each district, a demand for a hundred or more pieces of each type of instrument exists either already or potentially.

(ii) These instruments are used in jobs where the users will attach great value to dependable performance, maintenance and, if possible, a close technical understanding on the part of the supplier of the use to which the instrument is put.

(iii) Improvements in test instruments necessitated by changing pattern of use or made possible by innovations in instrument practice itself should reach the user quickly in the form of successive models, each technically much superior to the previous one.

It is clear that local manufacturers having a complement of competent design personnel will have a great advantage over both large centralized units as well as local entrepreneurs without technical backing. At the same time, the market for such instruments has to be constantly built up in order for manufacturers to survive. The technical backing required for a successful unit need neither be extensive with a large number of highly qualified scientists nor intensive with technical personnel of the type hard to find. All that is required is design talent, capable of bringing well-known designs into prototype and production stage. The commitments and the tasks are thus very limited, the markets are vast and ever expanding, the import substitution potential very high and the impact on the national economy very beneficial in directing part of industrial research in electronics to design and development of general purpose electronics test instruments.

The economics of such an effort can be seen from the following points.

(i) The cost of production for an instrument, including the input of materials, labour costs and overheads can be kept to within 70 per cent of the equivalent instrument abroad.

(ii) The cost of those components and primary materials, which will necessarily have to be imported during the next 3 to 5 years, can be kept to within 15 per cent of the cost of the equivalent instrument abroad.

(iii) The cost of design and development of most of the instruments can be kept within the price of 10 to 20 instruments.

(iv) The technical competence acquired by any group can be used with proper management to great competitive advantage on a continuing basis.

In view of the economic advantages, such work should commence in the country forthwith. If the private sector does not come forward to work within the guidelines provided, it may be due to a lack of vision and can be corrected only by Government organizations doing the work and passing on the benefits quickly to the public.

Industrial measuring and control instruments

Electronic instruments for measuring parameters such as humidity, temperature and thickness, often associated with control mechanisms offer great economics in industrial plants. To a great extent the pace of introduction of such innovations in India is limited because it is generally the practice to depend on a foreign collaborator for the design and supply of an entire plant. It will therefore take pioneering effort to break the existing conservatism and open the minds of the executives in other industries, who can be called the users, to the possibilities of cost reduction and quality control by using more and more electronic gadgets. The factors which

have to be taken into account in any programme of industrial research in this area are:

(i) There should be basic necessity and motivation on the part of the users to take advantage of the potential of electronics.

(ii) A high degree of competence and versatility is required on the part of the development group in order to bridge the gap between laboratory systems and practical dependable working installations in the plants of the users.

(iii) As a first step towards promoting the growth of such development groups, specific, economically justifiable and technically precise and feasible projects should be drawn up and given the wide publicity so that competent groups can come forward and undertake development work with clear time schedules and commitments in personnel and funds.

Electronic components

The most important area of fruitful industrial research in electronics will be the development of a rationalized set of components to cater to the needs of the whole country. The major pre-requisite is the formulation of specifications for such a rationalized set of components. It is a task which needs the scrutiny of the entire requirements of electronic equipment in the country, fixing the levels of technology to be attained in the coming years, defining projects for the development and production of equipment, relate the requirements of components, both qualitatively and quantitatively to the electronics industry so envisaged, rationalize the components for the benefit of those who have to design equipment as well as those who have to develop components and then lay down specific projects for the development and production of components. It is understood that the Electronics Committee under the Chairmanship of (the late) Dr H. J. Bhabha, appointed by the Government of India, has already carried out this technical task and will be submitting its report shortly to the Government. Any development work on electronic components outside such a thorough and systematic planning of the entire electronics industry is bound to be haphazard and fruitless effort.

As the technical pre-requisites have thus already been met and the development projects are likely to be defined soon, it is only necessary to illustrate the techno-economic aspects and for this an example is given below.

We shall consider miniature, high quality electrolytic capacitors. It is certain that professional electronic equipment to be produced in India will have to be transistorized in a year or two and large demands for these capacitors will then arise. It should therefore be worthwhile to develop tantalum capacitors, the general technology of which is well known, in a crash programme lasting not more than 2 years. At the same time, titanium and solid aluminium capacitors, for which the basic primary materials are abundant in India will have to be used in most of these applications say beyond five years. Therefore, the technology of these has to be developed by having a programme scheduled to develop the techniques and put these components into production in about five years. Any slackening of efforts in these directions will result in the country opening its eyes only when the import of miniature, high quality, electrolytic capacitors mounts and we are forced, by short term considerations, to buy from abroad the know-how

and production machinery for capacitors of certain types when these are on their way out in the advanced countries.

One hopes that the report of the Electronics Committee will contain detailed analysis and recommendations along these lines on all the important electronic components, so that this important part of industrial research in electronics could follow merely as a logical step in the implementation of the Committee's report.

Primary materials

Even as self-sufficiency in electronic equipment is meaningless without self-sufficiency in components, a similar relationship exists between components and primary materials. Any lack of understanding of this relationship will result in many distortions of the industrial structure in electronics. As an illustration, one can cite the manufacture of carbon film resistors where, even if the latest methods of production are obtained, say, with foreign collaboration, the project would be meaningless if the production of ceramic rods of the requisite quality is also not established simultaneously. In fact, in the wider national interest, it would be essential that the collaboration, supplemented by development work done in the country, should make it unnecessary for going in for further collaboration either to increase the production or to produce better resistors, such as the metal film resistors in future.

Production machinery

This brings us to an important aspect of industrial research which is economically and strategically very vital, namely the development of production machinery. The absence of the ability to design and install production machinery even by importing if necessary, certain components, tools and machines from abroad in the next few years, will be a serious drag on the development of the electronics industry unless particular cognizance is taken of this situation. The problem fails to be tackled with sustained effort due to a combination of circumstances. First, the manufacturer of a particular component has to face questions of installing production machinery only once in any project and that too at an advanced stage when time cannot be spent for getting the machines developed. The result is that an ad hoc solution, suited to the particular project on hand is adopted, often resulting in entrusting the design, supply and erection of the machinery to a foreign collaborator. Secondly, any indigenous development of components, carried out on a laboratory scale, does not get the support of a capable productionizing process and, for reasons of expediency, gives place to a completely productionized, though often obsolescent, component from a foreign collaborator. Thirdly, the practical play of forces is not conducive to a competent party putting in efforts to develop production machinery. If the user is not to be forced to import components in use to-day, the manufacturer has to produce them. The manufacturers will naturally go in for collaboration for the necessary plant and know-how rather than think of productionizing components which are yet to come into use and the development of which, though probably done in Indian laboratories already, is yet to be proved production worthy. The laboratories, with very little opportunity to do production runs, would naturally be unable to keep pace with the changing patterns of demands for components and to put the latest types of components into production at

short notice, thus reducing the confidence of both the user and the manufacturer in development efforts.

The problem of designing and installing production machinery is thus both technical and motivational, the solution of which will demand ideas and efforts yet to be unleashed. To what extent and in what manner laboratories, manufacturers, users and Government coordinate efforts is a question that we can fruitfully try to answer.

An Outline of the Plan for Self-sufficiency in Electronic Equipment

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A self-sufficient electronic industry is vital for our defence and for various other industries. The present condition in India underlines this necessity and makes it imperative to achieve this result as quickly as possible without much foreign help. This has become too obvious to need any emphasis.

In order to achieve self-sufficiency in the shortest possible time in as much equipment as possible, it is not possible to fritter away our resources which are limited. For the purpose, close coordination in the field of research and development is necessary. We have a number of research laboratories where applied research in electronics is carried on and the level of technical knowledge is also high. With some amount of coordination, it is possible to get excellent results. There is no reason why radars, high power transmitters and other vital electronic equipments should not be manufactured in this country, but we note with disappointment the fact that none of these equipments are manufactured.

Planning

In order to achieve self-sufficiency in this matter the whole scheme must be carefully planned and executed. However, it should be noted that to be effective, planning should be result-oriented. To be more effective, the planning must be directed from a central committee rather than by the various laboratories.

For speedy execution of the work, several industrial divisions have to be set up to deal with the manufacturers of the various types of equipments and components. In this connection a Central Industrial Planning Committee should be set up and under this committee several sub-committees should be organized to plan and set up the various industrial divisions. The industrial divisions with the type of equipment to be manufactured are indicated below.

Industrial Division	*Items to be manufactured by the various divisions*
Defence equipments	Radars, various other defence equipments, control equipments for missile, hybrid and other types of computers for control
Transmitter	High power broadcast transmitters

Laboratory equipments	Various types of measuring equipments, signal generators, oscillators, VTVM oscilloscope and other instruments
Components	Resistors, capacitors, microphones, loudspeakers and other components
Raw materials	Germanium, silicon, cathodes, phosphors, paper for capacitors (electrolytic and paper), photo-sensitive surfaces and other raw materials
Special valves and transistors	Magnetrons, klystrons, travelling wave tubes, C.R. tubes, television tubes, all types of transistors and photo-multipliers

For organizing the various divisions, attempt should be made to utilize the existing industries as much as possible. For example for special valves and transistors, the Bharat Electronics Ltd (BEL) and other transistor manufacturing industries may be in a position to manufacture these items with the technical know-how provided by our own laboratories. Again it seems that the Central Electronics Engineering Research Institute, Pilani (CEERI) is quite competent to provide this technical know-how within reasonable time.

For all the proposed industrial divisions there will be many items for which technical know-how will be available in varying degree. First of all the level of know-how should be brought to pre-production stage. The procedure for attaining the technical know-how up to production level will be different for the various items in all the industrial divisions. There are many ways in which this can be done.

The items for each division should first be carefully selected and then the development work to be done for each of the items assessed and distributed to various laboratories.

Production

The production procedure for the various divisions will, necessarily be different. Some suggestions are made here for consideration of the Electronics Group Committee.

Defence equipment. For this division we should first divide the items into two groups: (1) items which are already used in our defence systems and (2) new items that should be introduced in our defence systems.

For the group (1), the items may be processed for production without much difficulty. Necessary changes in the frequency, power and modulation should first of all be assessed. For production of these items, special valves and components may have to be imported at the beginning. Equivalent BEL valves should be utilized as much as possible. For the special valves, it should be possible to get equivalent tubes from Japan, USSR, Czechoslovakia, France and other European countries. At the same time research and development work on these special valves and components should be started so that with the limited foreign exchange the production of vital defence equipments may be continued uninterrupted.

For the items in group (2), research and development work should be started with close collaboration between the various laboratories. As far as possible, some time schedule should be maintained for the successive

phases of the development. After development of these items, manufacture of such valves and components should be taken up by industrial divisions of Components, Raw materials and Special items.

High-power transmitters. India should immediately start manufacturing high-power broadcast transmitters, because with rapidly expanding broadcasting programme, we will require a large number of transmitters of various power rating. Further there is a large potential market for export. We should manufacture transmitters with power rating of 5, 10, 50 and 100 kW. When these transmitters are produced, attempt should be made to extend the power rating to 1000 kW.

The manufacturing programme should again be split up into two parts, i.e. studio equipment and R-F and modulator sections. Naturally, the research laboratory of All India Radio (AIR) shoud be used for development and processing this manufacturing programme.

After suitable modification of the existing studio equipment, the manufacturing programme may be entrusted to existing industries which have allied production programme. In this connection manufacture of microphone and loudspeaker should also be undertaken by the Components division.

The AIR should select the transmitters for each category and after suitable modification from indigenous angle, the production should be undertaken. High power tubes have to be imported at the beginning. Immediate development work for high power tubes may be undertaken by CEERI.

Laboratory equipments. Several representative types of each equipment should be selected and after suitable modification manufacture of these instruments should be entrusted to the existing industries. Microwave instruments should preferably be developed and processed by CEERI.

Components. There are already some industries in this field. The production should be augmented. Manufacture of microphones and loudspeakers should also be entrusted to private industries after the development of these items in some suitable laboratories.

Raw materials. The development of items in this division will require much resources and sustained research work. For this a special research laboratory should be established. The laboratory would require a number of chemists, physicists, metallurgists and electronic engineers in the research staff. Once the know-how is available the production may be made in several units. Such a national research laboratory is long overdue and it will pay rich dividends later in many industries.

Special valves and transmitters. The development work for items in this division may be carried out in CEERI with necessary augmentation of the facilities. The production of these items may be done by BEL and other transistor manufacturing units.

Development Centres for Instruments

All India Instrument Manufacturers
& Dealers Association
Bombay

The instruments industry in India is barely 25 years old. No doubt, there were a few isolated units, say, in Ambala, Bombay, Calcutta, Poona or Roorkee, even as far back as fifty years ago. These units were engaged in the manufacture of simple laboratory instruments and appliances. The production of instruments reached a sizeable figure only by 1955. Today the production of scientific instruments is estimated at about Rs 7–8 crores per annum.

By its very nature, the instruments industry is essentially a small scale industry even in the advanced countries. Out of about 75–80 units registered with the Directorate-General of Technical Development, hardly a handful could be termed really big units, others being medium scale factories. The number of manufacturers in the small scale sector is estimated at about 300 units and an equal number or even more, unregistered units (not covered by the factories act), are in the manufacture of instruments or their parts. These units, small or big, manufacture a fairly large variety of instruments like electrical, electronic, optical, medical and electromedical and survey instruments. There is still a great scope for manufacture of many more types of instruments, which are being presently imported. Given necessary resources some of these instruments could be manufactured indigenously thereby reducing our import bill.

The instruments industry being new the developmental activities and development process are rather slow. Most of the manufacturers produce relatively a small and similar range of instruments. Most of these small units cannot afford to have research and development activity worth the name.

Against this background, the estimates of production and requirements of instruments in the Fourth Five-Year Plan appear stupendous. The figures are given below :

	Production	*Requirements*
1966–67	Rs 25 crores	Rs 50 crores
1970–71	Rs 60 crores	Rs 120 crores

These figures cover all types of scientific and industrial instruments, apparatus etc., including commercial instruments like home service meters, water meters, time switches etc. To achieve these targets the instrument manufacturers, small and big, will have to concentrate on research and development work.

Need for self-sufficiency

The present political situation has helped the people realize the necessity of self-reliance. We have to manufacture all the essential articles both for civil and military purposes. Also, the limited foreign exchange available has to be scrupulously utilized. The instrument industry also, in tune with the overall policies dictated by the circumstances, has to think of expansion without relying much on imports. There are two different aspects of imports substitution: (i) Substitution of imported complete instruments by indigenous manufacture and (ii) Substitution of imported components and raw materials by indigenous products.

Our present production is estimated at Rs 13 to 15 crores, as against the demand for instruments of all types estimated at about Rs 40 crores, the difference being met by imports to a considerable extent. The foreign exchange component of the instrument industry is on an average, about 10 to 15 per cent of the total cost structure of the industry, being composed of components, raw materials and equipment costs.

A step to bridge the gap has been taken by having technical collaborations with foreign manufacturers. But this is a short term measure, and unless such joint ventures concentrate on local development work, it is feared that the industry shall again fall behind. Further in the present political circumstances, collaboration terms may not be easy.

It is therefore imperative that the instrument industry has to meet the situation by research and development activities, jointly or individually. These activities comprise the following aspects:

(i) Development of instruments, being presently imported.

(ii) Development of indigenous substitutes for imported raw materials and components.

(iii) Research into design of instruments for newer applications to meet the growing requirements of new industries and social activities.

(iv) Development of new manufacturing processes for cost reduction.

As the instrument industry in India is mainly in the small scale sector, they have little resources for undertaking development work.

Research and development

The industry should be able to receive the necessary assistance towards development projects of common application, from the national laboratories. Some of the national laboratories and industrial research associations like the National Physical Laboratory, the Central Electronics Engineering Research Institute, the Central Glass & Ceramic Research Institute, the Ahmedabad Textile Industry's Research Association, and the Shri Ram Institute for Industrial Research, have developed a few instruments and components and have made them available to industry. The general experience, however, is that in most cases the transformation of a laboratory model to a factory model or even to a prototype stage is very costly both in terms of financial and material resources.

Expenditure on research

Research or development work involves substantial money. The returns are not likely to accrue immediately. The manufacturers in the

advanced countries, being big as compared to our manufacturers, set aside on an average 10 per cent of their turnover for research and development. In absolute values, the amounts spent on research by these units are fantastic. It is true, that the average Indian manufacturers, even after pooling their resources, cannot afford to have a good research organization. Financial assistance from Government is essential. The Indian Government has therefore offered to industries, through the CSIR, grants for starting industrial research associations for different groups of industries.

Development centres

The instrument industry is composed of diverse groups like optical instruments, electronic instruments, mechanical instruments, industrial instruments, etc., which differ widely not only in the applications but also in the manufacturing processes. The problems are therefore varied. Moreover, the number of units manufacturing different types of instruments, except for a few instruments of common application, is comparatively small.

Hence, at least for some time to come, a Central Industrial Research Organization covering all branches of the instrument industry may not be ideal. Instead a network of development centres in different parts of the country is more welcome. The instrument industry though scattered all over India, is concentrated in certain areas, like Bombay, Poona, Hyderabad, Bangalore, Madras, Calcutta, Delhi, Roorkee and Ambala. Moreover most of these places have a preponderance of some particular types of instruments only, like school and college apparatus at Ambala, survey instruments at Roorkee, electrical heating and electronic instruments in Bombay etc. Each of these key-centres could have a development centre (laboratory) for the particular group of instruments it produces. The programme of setting up of such Centres could be suitably phased out. The Association recommends that such centres should be started at least in Bombay, Calcutta, Delhi and Madras and offers its full cooperation in setting up of such centres. As an experimental measure, the first such centre for electrical and electronic instruments could be started in Bombay where a fairly large number of factories manufacturing electrical and electronic instruments exist. The Association has its head office in Bombay and is pleased to offer all assistance to bring such project into reality and later even in its administration.

The Scheme envisaged by the Association contemplates a tripartite arrangement among the Council of Scientific & Industrial Research, the Small Industries Service Institute (SISI) and the All-India Instrument Manufacturers & Dealers Association.

The CSIR offers 50 per cent grant both on recurring and capital expenditure, for industrial research laboratories and could therefore contribute to meet the expenses of this Development Centre. As the amount involved is small, it is pleaded that the CSIR may contribute the capital expenditure fully. The CSIR through the Central Scientific Instruments Organization, could also offer technical assistance and procure services of foreign advisers, whenever necessary and possible. The CSIR could also provide effective coordination with other national laboratories and research institutions.

The Small Industries Service Institute in Bombay may be requested to give space for housing the Development Centre. The SISI also has

sufficient processing and testing equipment which could be advantageously used by the centre. The centre will have to purchase some specialized equipment, which will be made available to the SISI. The SISI is already being consulted by the small instrument manufacturers for some of their general problems. The SISI, Bombay is already having a surgical instruments extension centre attached to it. By making the SISI as a partner in this joint venture, the capital costs could be reduced considerably. If however, by chance for some reasons the SISI is not able to join such a venture, the Government of Maharashtra could be approached for allotting a small piece of land free of charge or on nominal rent in an industrial estate or at any convenient place in Greater Bombay.

The Association is willing to undertake the administrative responsibility in getting this project completed. The proposed centre could be run by the Association as one of its activities or if so desired, by sponsoring a separate organization under its auspices.

The facilities at the centre would be available to its members only. IMDA being the sponsor, its members will have preferential treatment in matters like fees, subscription etc. The Association shall endeavour to enroll all its members from Bombay as the members of the development centres.

The Executive Committee of the Centre will have representatives from the Association, the CSIR and the SISI. Besides, the IMDA could also guide in preparing schedule of the work to be handled by the centre.

The funds for the centre will be realized through the grants from the CSIR, subscription from members and test fees.

The centre would undertake following activities:

(i) Developing substitutes for imported components and raw materials.

(ii) Providing test facilities for instruments.

(iii) Organizing a documentation centre and providing technical information service.

(iv) Developing new circuits and designs.

(v) Processing the instruments developed at the national laboratories and research institutions, to a prototype stage if necessary.

(vi) Developing industrial application of the academic research pertaining to instruments. The members shall have right to suggest items for development work. The executive committee with the advice of the Association could decide the priority depending on the utility of the particular items.

With the experience that may be gained in this project the next centre may be started in Delhi for optical instruments and general physics apparatus.

Development and Maximum Utilization of Resources for Instrument Industry

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By dropping the word 'scientific' out of the scientific instrument terminology, we have tried to embody in the definition all those instruments which were earlier not in existence or were classified under different heads. Even then, the definition of instrument is rather vague; some include within the purview of instruments definition, commercial items such as switchboard instruments, house service meters, water meters, time switches etc. and others do not. Interpreting the word instrument in a wider sense, the earlier projected demand for these products by the end of the Fourth Five-Year Plan was estimated at Rs 120 crores per year, whereas the present production is of the order of Rs 13 to 15 crores. These estimates show that there is a wide gap between production and estimated demand during the years to come, and unless a scientific planned approach is made to achieve near self-sufficiency, the country will either have to depend on import, or suffer the shortage because of nonavailability. The instrument industry as such is of very recent origin. Whereas there was no worthwhile production a few years ago, it is now producing a wide range of simpler instruments, which more or less meet the demand of scientific institutions teaching up to graduate science courses and is able to meet substantial demand of commercial items. In fact, the industry has produced more house service meters than the country can consume at present. This being labour based industry, has good export potentialities, and hence by concerted planned efforts, we can reach not only near self-sufficiency, but may be able to export in good numbers at least simple instruments to our neighbouring countries.

The progress although substantial during the last few years is mainly confined towards the production of simpler items in the absence of technical resources. Quite a large number of manufacturers are almost all engaged in the manufacture of common items, such as balances, ovens, incubators, microscopes, levels, gas plants, centrifuges, stirrers etc., with the result that whereas the country is starved in respect of sophisticated instruments, there is keen competition and price reduction, resulting in the lowering of the quality of simple items manufactured by such firms.

Resources

For scientific development, the resources can be classified as under:

(i) Technical know-how

(ii) Finance

(iii) Test equipment and specialized production machinery

(iv) Critical components and raw materials

Technical know-how

Technical know-how is the most telling factor among all the resources mentioned, and therefore our main task should be to develop technical know-how on priority. There are various steps which have to be considered in this context.

(a) The existing manufacturing units who have developed their own know-how should be requested to have their own research & development department for taking up the production of more advanced type of instruments, leaving the simple items that they are manufacturing now to the newcomers. They must also have a systematic in-plant training of technicians, inspectors and research workers.

(b) CSIR should encourage setting up of development cells attached to the existing manufacturing units by extending financial grants and other facilities. This was the practice earlier, but recently for reasons unknown, the scheme has been shelved, and therefore needs revival.

(c) Small manufacturing units should establish cooperative research organization, so that the problems from a group of industries engaged in production of similar type of instruments can be solved with commonly created facilities and resources.

(d) National laboratories should take up the development of sophisticated instruments which are needed in the country but not produced, and after developing these instruments should lease them out to private firms to manufacture. This practice can also be followed by various defence research organizations.

(e) The Government and CSIR should start post-graduate courses in instrument technology. This should be a minimum 3-year course, so that the graduates who complete the course are capable of taking up designing of new products independently, in a specialized field.

(f) There should be a close liaison between the industry and government and some government research institutions, so that items required in the various industries can be taken up for development work in these institutions, on nominal payment basis. Also Professors and Lecturers in the research institutions should have freedom to work as consultants in various industries.

(g) Although there are quite a few training centres organized by the Central Government in different parts of the country for the training of instrument technicians, the training imparted suffers both in quality and quantity. These institutions in the first instance restrict their training programme to a very few items, and then the trainees do not have sufficient raw materials or equipment to do experimental work to the extent required. These institutions should have a wider training programme and more financial resources for imparting training facilities.

Finance

At the moment, there is dearth of finance, both internal and external. So far as internal finance is concerned, the difficulty is due to the discriminatory fiscal and monetary policies adopted by the Government. In

spite of the importance of the instrument industry, it is not included in the list of essential industries, and therefore this industry is denied certain tax concessions, and is not able to attract enough finances. Small scale industries do have certain loan facilities from various State and Schedule banks, but the procedural delay encountered comes in the way of easy negotiations, and therefore they have to be simplified.

Coming to external finances, there is acute shortage of foreign exchange, but even then something can certainly be done, because this industry needs very low percentage of external finances, when only critical components and raw materials are to be imported, as compared to the import of complete instruments. The Government therefore should set aside a reasonable amount of foreign exchange to meet the immediate requirement of these critical components, raw materials, and particularly test instruments for the industry. The All-India Instrument Manufacturers & Dealers Association pleaded in the past for an allocation of Rs 2.5 crores foreign exchange for this industry during the Third Five-Year Plan. This was accepted in principle, but was not implemented. The estimated demand of foreign exchange to achieve self-sufficiency in instruments during the Fourth Five-Year Plan is of the order of Rs 6 crores per annum, which can now be reduced in view of the change in atmosphere in favour of self-reliance and self-sufficiency, but something must be done on priority basis to meet the requirement of the industry.

Machinery and test equipment

This industry being of highly technical nature needs specialized machinery for the fabrications of delicate components and parts. Similarly it needs standard and sub-standard test instruments for testing and calibration of instruments to be produced. In a situation when even production of sophisticated instruments is not there, some way has to be found out to provide the needed machinery and test equipment. Small manufacturing units are at the moment happily placed, as they can import some of their requirements through National Small Industries Corporation under German and Japanese credit, but medium and large-sized industries have to encounter unsurmountable hurdles to have proper machines and test equipment. This problem can only be solved by having a certain allocation of foreign exchange for this industry as stated above.

Components and raw materials

The Industry only needs marginally required components and raw materials, but they are highly essential to maintain the quality of end products. It is, therefore, necessary that CSIR in association with All-India Instrument Manufacturers & Dealers Association take up the study of minimum requirement of components and raw materials for each group of instruments. As 'instrument' connotes a wide range of products, some of which are purely electronical, some electrical, some optical, some pneumatic and so on the requirement of components and raw materials will differ widely. The assessment of critical components and raw materials can be done after a systematic grouping of instruments in various groups and a detailed study in the light of the present availability within the country and essential requirements.

Maximum utilization of resources

Creating resources is not the end in itself; steps have to be taken for their maximum utilization. As already mentioned 'instrument'

covers a very wide field, and the requirement of each group of instrument varies in nature. In order to make maximum utilization of the resources already decided upon, the following steps should be taken.

Creation of functional industrial estates

For the instrument industry, I would suggest the following functional industrial estates:

(a) Optical instruments
(b) Electronic instruments
(c) Mechanical instruments
(d) Horological instruments
(e) Electrical instruments
(f) Pneumatic instruments

I need not mention the various names of instruments to be covered by each group, because we know enough about the same, and if necessary more groups can be created if after a detailed study we find that instruments are not covered by the above groups, from the consideration of manufacturing problems and the required facilities.

These Functional Industrial Estates should be equipped with common development and testing facilities, specialized production machinery and tool room and ancillary units which will be peculiar to each group or industry. In this manner, it will be possible to make maximum use of the imported specialized machinery and test equipment. Normally it has been observed that quite a few industries, although they have a wide range of such machinery of their own, are either not making full use of the same, as they do not have proper load, or in the existing circumstances they are short of even a few additional machinery and test equipment, which may be available in another unit, but they may not be utilizing the same fully.

Bank for raw materials and components

On the basis of detailed study of components and raw materials required for each group of instrument industry, a bank should be created to house essential imported raw materials and components. At the moment some of the industrial units have too much of these items, which they cannot even consume in a reasonable time, and others suffer for want of these components. This situation has been created because of the present licensing procedures. Once an entrepreneur has received the licence, he wants to utilize the licence to the maximum extent, irrespective of whether he will be able to utilize the components within a reasonable time, and thereby his inventory increases. A large inventory is a loss not only in terms of interest paid on the money locked up, which itself is very high, but because it is estimated that the incidence is of the order of 30 to 35 per cent if we take into account other factors, such as breakage, storage charges, insurance obsolescence factor, pilferage etc. The present import licensing policy is restrictive in terms of value and quantity of each component and raw materials, with the result that often, full production cannot be achieved because of shortage of some minor or marginally quite essential components and raw materials. By having a common pool, inventory of individual units can be reduced. The various manufacturing units will be able to draw from the common pool their requirement of raw materials and components in quantities they need, and as and when they require the same.

Blanket import licence

As a corollary of the above, I would suggest that a blanket foreign exchange should be given to each and every unit and each group depending on its production capacity and best performance, so that within the foreign exchange allotted, the unit is free to import enough essential items, which it cannot obtain otherwise or make in its own unit. Such a policy is in force in the case of some State enterprises, and partially in the case of some State enterprises controlled by DGTD under Industries Development & Control Act. The small scale units are the most sufferers in this respect and they need sympathetic consideration and reorientation of import policy as applicable to them.

Standardization

The various manufacturing units should realize the importance of standardization. A clear understanding of the standardization will be helpful in the reduction of inventory of items and actual reduction in the cost of the end products. I would strongly suggest to instrument manufacturers that for each instrument in production they prepare a display board wherein they can show each component that goes into the production of the complete instrument. This display board can be divided into two sections, one showing the imported components and raw materials and the other indigenous components or components of their own manufacture. These components can be shifted from one section to another as more and more utilization proceeds.

The standards to be finalized by ISI should be workable standards, so that the end product can give the desired performance, without too much of rigidity. The standards to be finalized should be in keeping with the facilities available within the country.

There are cases when some of the manufacturers have collaboration agreements with various firms situated in different countries, and hence are obliged to produce the products in accordance with the standard practice of those individual countries. Without our own standardization, the problems are bound to increase and therefore call for immediate attention to this aspect. Even taking the case of most common items like bolts and screws, we have innumerable headaches, unless the problem is tackled from the very beginning in a planned manner. The management of all these units should be very much conscious of the importance of standardization and then percolate the same idea to the personnel of the departments, specially set up for this purpose. I strongly feel that irrespective of the size of the industrial venture, a standardization unit is a must in it.

Value analysis

Value analysis is a modern concept and has gained importance very recently. It is stated that this is the latest and the most technological revolution in the industrial field, after the industrial revolution of the nineteenth century. Value analysis in simple language means a study of the product and the components that go to make up the product from the functional point of view, with an open mind, and to simplify the components and the end product, without sacrificing the performance. This sort of simplification will result in enormous saving, will introduce import substitution, and many times improve the product. The task is to be entrusted to a new group of engineers who are not bound to the traditions

of the unit. They should have fresh approach to tackle the problem, must have a technological and analytical mind to understand the things and functioning of each component and the end product. It has been said that any process which has been in existence in any manufacturing unit for more than 10 years is not only obsolete, but is replaced by the new process. Old workers bound to tradition, or by habit or by use of the process in existence, are inherently opposed to new ideas. It is, therefore, only the young blood who can do this responsible task successfully.

Phased programme

At present most of the industrial licences are issued on the consideration of phased programme of each unit, and there is insistence that a phased programme should be such that each individual manufacturing unit attains near self-sufficiency within 3 to 5 years. Such a policy although desirable from certain angles is bound to create unutilized capacity. Take for instance a unit engaged in the manufacture of microscopes. If this unit has to be self-sufficient, it has to make all its optics required by it. The production of optics is a specialized job by itself, for which large number of machinery and test equipment have to be installed, whereas the production from this optical unit will be so much that it will not be fully consumed by the main unit, with the result that the optical unit will be working only for part of the time, or for a few weeks in a year. On the contrary, if this phased programme is based on a group of industries taken as a whole, then there will be a more realistic approach to the problem. Some units can engage themselves for the purpose of assembling of complete units and others can be entrusted with the task of manufacturing constituent components and processing of raw materials etc. I, therefore, strongly suggest that to begin with there should be an assessment in the existing units as to what they are producing, both complete items and components, then assess the total requirements of instruments falling in that group and break it into complete units, as well as components and raw materials. Wherever there is shortage that has to be fulfilled.

These factors call for serious thinking so that effective steps are taken to meet our own requirements and provide for export. There is need to provide import of prototype samples to enable the industry develop new models. This practice was followed in Japan, with the result that this country is not only self-sufficient in many fields, but is able to export latest products and even technical know-how to the highly developed countries of America and Europe. A great advantage is that the instrument industry requires intensive labour and fortunately our country has abundance of labour and it is only a question of proper training and utilization of labour.

Some Problems Relating to Electronic Components

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It is becoming apparent that major changes in component design are necessary in view of the shortage of raw materials. Pack sets and miniature equipments led to reduction of the size of components. All this led to establishments and industry developing new materials and components intended to satisfy the many conflicting requirements. Research and development work will continue in order to improve the performance of components even as we know them today.

It is a recognized fact the electronics industry has made a good progress in the manufacture of components but has not achieved self-sufficiency. In this report the problems pertaining to essential components of the radio industry are dealt with.

The problems vary with the nature of the individual components. They are broadly classified as under:

(i) Raw material
(ii) Process technique
(iii) Equipment

The components and materials that need immediate attention are:

(i) Variable capacitors
Fixed capacitors
(ii) Loudspeakers
(iii) Trimmers
(iv) Variable carbon composition tracks
(v) Waxes

Variable capacitors : Aluminium material

There are two main requirements in broadcast receiver type of variable capacitor: (1) Frequency stability so that the tuning positions of the station do not change. (2) The vanes must be rigidly fixed to prevent microphony.

To achieve frequency stability, there must be no short term or long term change in vane spacing or in the dimensions of the frame. Vanes for capacitors of the broadcast type are generally punched from aluminium strip. The strip is rolled to a very close tolerance to achieve the required capacitance tolerance when assembled. After punching, heat treatment

of the vanes is desirable. It is essential that the flatness and thickness of the vane material are as perfect as possible after the processing stages.

To prevent microphony there must be no mechanical resonance over the audio range of frequencies; a greater emphasis is placed on the rigidity of frame and mounting.

It is necessary to fabricate sheets of close tolerance and correct hardness so that vanes could be punched out from such sheets thereby eliminating import of special sheets.

Fixed capacitors

Capacitors are generally made by rolling a dielectric material like paper and metallized polystyrene, polythene, polytetrafluoroethylene etc., as insulation between metal foils and filling with an impregnant or otherwise.

All the dielectric materials are being imported. They are of a special electrical grade. The capacitor tissue paper employed for this purpose has become a highly specialized manufacture. Amongst insulating papers it takes a special place, because in a capacitor all its properties as a dielectric, viz. dielectric constant, dielectric after-effect, insulation resistance and electric strength are exhibited to the full. The following specifications are recommended :

Thickness	$\pm$ 6% (8 μ and 12 μ)
Specific gravity	$\pm$ 6% (1–1.26)
Surface area	$\pm$ 6%
Moisture content	5–7%
Porosity	0.001–0.0001 cm.^{3}/s.
Conductivity	40–60 mhos
Chloride ion	Less than 0.001%
Ash	Approx. 0.3%

Winding machines for capacitors should be compact and of high speed. However, these are not being manufactured in India. It should, be possible to manufacture such machines in India to step up the production of fixed capacitors. The following may be undertaken :

(i) Development of dielectrics, paper, polystyrene, etc.

(ii) Improvement of quality of aluminium foil.

(iii) Investigation into the economics of substitution of condenser tissue paper by indigenous production.

Loudspeakers

The pulp for making loudspeaker cones is being imported since a suitable impregnated paper pulp is not available in India. However, it can be developed and processed to meet the requirements of speakers. The cone must be a compromise between strength and lightness.

Trimmers : Base steatite — mica compression type

They are usually of fairly simple design and consist of a single mica plate or series of mica plates interleaved with spring brass or

phosphor-bronze plates, suitably finished, which are compressed by screw adjustment to vary the capacitance. The base of the capacitor for a good design is usually made of low-loss-permittivity steatite.

Raw materials for ceramic base are available in India. These have to be developed to suit the specifications for production of trimmers.

Variable carbon composition tracks

These variable resistors are made by continuously spraying an insulating strip with carbon composition and curing at a high temperature. The tracks are then stamped out by automatic die-presses. Grading of the tracks for log laws is carried out by selective spraying through suitable mask and with different carbon mixtures. The base material for the carbon composition is colloidal carbon. The composition of the mixture will vary from manufacturer to manufacturer. The essential raw material is not being manufactured in India. It will be a great advantage and relief to manufacturers if colloidal carbon is manufactured in India.

Waxes

All winding parts are impregnated in suitable waxes to give protection from humidity. Paper capacitors are impregnated in a suitable wax/jelly to improve the electrical characteristics. It is difficult to describe in a few words the desirable properties of wax for dipping coils, but the most important ones are: convenient melting point above 75°C., suitable viscosity for easy dipping at 120°C., low dielectric loss, high chemical stability, freedom from electrolytes, freedom from brittleness at low temperatures, microcrystalline structure and low water absorption and good resistance to wetting or emulsifying with water.

The waxes should be pure mineral hydrocarbon base. They should be non-toxic and should not react on metals of any description. They should be free of synthetics and chemicals to raise apparent melting point. With the setting up of refineries for petroleum products, these waxes can be made in India if a suitable process is evolved.

Some Aspects of Research and Development in Radio Industry in India Today

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The radio industry in general has been quick to appreciate the necessity for integration and the development of local raw materials. In course of time it has managed to become self-sufficient to a large extent, by constant development work and search for indigenous procurement.

Basic materials

Apart from the general difficulties confronting all industrial development, the radio and electronics industry has a number of specific problems with regard to its material requirements. The radio industry during the last ten years has changed over from conventional manufacturing techniques to development and manufacture of portable and table sets with the transistor as basic element. Most of these sets are executed with printed wiring. For the execution of this programme the radio manufacturers in India are confronted with specific problems related to the nature of some of the basic materials for the manufacture of components used in the respective designs. Some of these problems are outlined below:

(i) Raw materials of exceptionally high quality and purity are required for the manufacture of modern electrical components. For instance, 99.99 per cent purity aluminium for the manufacture of miniature electrolytic condensers.

(ii) The quantity of such raw materials required is mostly small and the specifications so stringent that, seen from an economical angle, such orders are not always attractive to the suppliers.

(iii) The problem of obtaining consistent supplies. In a sales market it is not always easy to convince the supplier of the value of standardization and quality.

(iv) Climatic conditions demanding tropicalization of certain products place more stringent demands on the quality of basic raw materials.

The problem of indigenous substitution and integration may be discussed under the following three heads:

(i) Development of substitutes for the imported raw materials.

(ii) Indigenous manufacture of essential components hitherto imported.

(iii) Measures through which the programme of Industrial Research could be oriented to the needs and requirements of Industry.

Substitutes for imported raw materials

In general the time lag involved in this development takes at least 2 years from the time when preliminary enquiries are made until the date when the item enters production. A number of steps are involved in this process :

(a) A market survey to discover a number of suppliers.

(b) Analysis and functional laboratory trials to assess the most suitable material.

(c) The material of the required quality may not be available. The purification or modification of available material can sometimes be achieved through mutual cooperation with the suppliers : for instance, through the supply of know-how and technical information. If as a result of these efforts the raw material which conforms to the manufacturing specification is obtained, it could be directly substituted in the manufacturing process.

(d) When the material is such that it requires a new formulation of the product and change in the specifications, a considerable amount of laboratory investigation has to be carried out to ensure that there is no alteration in the essential parameters or in the ultimate quality of the product.

Indigenous manufacture of essential components hitherto imported

A large part of the electronic components used by radio manufacturers in India are now manufactured indigenously. This has been achieved by systematic substitution of various ingredients over a long period of time. It will be appreciated that since the basic raw material for the manufacture of electronic components is of a specific nature, such material is still imported. The rapid integration in this field has been made possible by development laboratories and chemical laboratories in close cooperation with the manufacturing units. When planning the integration of any component, the following considerations are borne in mind :

(a) Early substitution of the more expensive raw material constituents so as to effect maximum saving of foreign exchange.

(b) Avoidance of any sacrifice in the essential properties and quality of the components.

(c) To avoid as far as possible sacrificing modern technical advances for the sake of a small saving in import. For instance, maintaining the quality of our products within international standards.

Finally, the decision to integrate or not to integrate must take into consideration the saving or loss to the national economy. There is little point in trying to manufacture a certain piecepart or component which only costs Rs 3 to 4,000 c.i.f. per annum, whilst the import value of the machinery required to produce the piecepart or component is to the tune of Rs 2 to 3 lakhs.

Industrial research oriented to the needs of industry

As expressed above, one of the major problems confronting the further development of the radio industry in India is the lack of basic raw materials of the required specifications, obtainable in the quantities required. In this connection we may mention aluminium foils, polester foils, copper

foils, winding wires of specific nature, cadmium, chemicals etc. Since most of the radio manufacturers in India have already integrated the manufacture of the components, it is in this field where a common effort of industries in a centralized manner may be of advantage.

The total integration efforts can now be sub-divided into two broad categories :

(i) Integration of the manufacture of components by each radio industry individually

(ii) Further development of the local supply of basic raw materials needed by radio manufacturers in India

(a) As far as the last point is concerned, it has to be appreciated that the quantities of most of the raw materials required by the individual firms cannot be manufactured by them on an economically sound basis but by combining the total requirements this may be achieved. To this effect the possibilities of developing the national industries should be investigated in detail suggesting improved methods of refinement and by making more resources available to encourage the production of better quality of basic raw materials.

(b) In this connection guidance should be given to the Governmental departments regarding the desirability to continue the import of certain basic items if indigenous procurement does not appear to be economic, the ultimate goal of all industrial research development being to establish competitive industries.

Applied Optics at the Indian Institute of Technology, Delhi

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With the success achieved in the production of some varieties of optical glasses in India and the increasing difficulties felt in the procurement of foreign exchange, the industry has to shoulder the responsibility of producing optical components required for optical instruments. Optical instruments requiring the use of optical glass, vary over a very wide range—from simple instrument for use in school to highly sophisticated equipment required for research and defence. Considerable technical know-how and skill are required in the production of the sophisticated instruments for satisfactory performance. To meet this challenge one could expect that an intense activity in this field would start as a result of the availability of indigenous optical glass. This activity would obviously be in the form of rapid expansion of the activities in the firms already engaged in the production of optical components and the emergence of new industrial units for this purpose.

The Indian Institute of Technology instituted a Postgraduate Course in Applied Optics with a view to meet the requirements of personnel for manning these industries.

As the Institute is assisted by the British Govt and the Federation of British Industries, arrangements were made for setting up an Applied Optics group in the Physics Department with the close cooperation of the Applied Optics Department of the Imperial College, London.

The main objectives of the optical group are :

(i) Postgraduate training and research in different branches of Applied Optics including Lens Design.

(ii) The development of technical know-how and skill required in the production of precision optical components and the training of suitable groups of persons who would be able to handle the large scale production of such components both in the public and the private sectors.

The laboratories are now equipped with the latest machinery and testing equipment supplied by UK. Mention may be made of the few major items :

1. Roughing Machine
2. Curve Generator (Spherical Grinder)
3. Slitting Machine
4. Automatic Grinding & Polishing Machines
5. Vacuum Evaporation Unit for Thin Film
6. Precision Spherometer
7. Angle Dekkor
8. Thickness Measuring Gauges
9. Binocular Testing Bench

10. Hand Polishing Machine
11. Centring and Edging Machine
12. Twyman & Green Interferometer

A nucleus of teachers and technicians for this group has been arranged with the assistance of the Applied Optics Division of the Imperial College, London. The activities of the group started with a 3-week Short Course in June 1964 for persons engaged in the optical industry. A 1-year Post-M.Sc. Diploma Course was instituted in July 1964. A 6-months technician training course was conducted with the assistance of Mr James, a technician from United Kingdom. During this time optical workshop techniques were developed for the fabrication of the precision optical components like:

(i) Achromatic Lenses from specific designs available.

(ii) Optical flat with surfaces worked to better than λ 10.

(iii) Beam Splitters with parallelism of the order of a 2 to 3 seconds of arc.

(iv) Angle standards in the form of prisms with an accuracy of the order of 2 to 3 sec. of arc.

(v) Concave mirrors up to 6 in. aperture with surface worked to better than λ 10.

Due to the present emergency the activities of the group are being extended and a Pilot Plant has been set up with the cooperation of our Mechanical Engineering Department, Central Workshops and the Metrology Laboratory, with the following objectives:

(i) Development of prototype of optical instruments.

(ii) Design of fabrication machinery and testing equipment in simple form useful for undertaking some particular components. It is normal experience that sophisticated imported machinery and testing instruments are often meant for satisfying more than one requirement and it is neither necessary nor desirable to copy a unit of that type when a much simpler unit may be sufficient when one is interested in the production of certain specific items.

(iii) Collaboration with the defence department in developing techniques for roof prisms, microscope optics and multilayer coatings.

(iv) Making precision optical components needed in small quantities by individual research workers in universities and research institutions.

(v) Offer of facilities for individual manufactures for testing their products.

Groups of persons from the industries would be attached with these projects during the development of the techniques and prototypes so that the projects after completion can be handed over to them after satisfactory completion.

It may be stressed that it would now be possible to go in for the manufacture of fairly large variety of optical components without the necessity of foreign exchange. Most of the machinery, abrasives, pitch and tools etc. required for this purpose can be obtained from indigenous sources.

We hope that our activities would be able to make some contribution to the optical industry which is now trying to rely on indigenous skill and material for its development.

Details of the various courses which are being conducted and the facilities which the institution can offer to individuals and industries, interested in the manufacture of precision optical instruments are given in some brochure which are available in the department.

Development of Microscope Optics Industry in India

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During the rapid industrialization of India in the post-independence era, some progress has already been made in the production of optical instruments in the country, but we are still far from being self-sufficient. Leaving apart the sophisticated type of instruments required in the maintenance of standards, the requirement in respect of even simple industrial, research, andcontrol instruments is still met through imports. The imports of microscopes, telescopes and optical instruments parts and appliances amounted to Rs 45.86 lakhs[1] during 1964–65. Furthermore, the import in respect of microscopes has always been consistent and it has depleted our meagre foreign exchange resources during the last five years by an amount equivalent to Rs 1.68 crores approximately.

It is heartening to note that during the past two decades, quite a few indigenous industrial units manufacturing mechanical components of microscopes have sprung up in the country. For guidance of indigenous manufacturing units, Indian Standards Institution (ISI) has already laid down specifications[2] in respect of the dimensions for general purpose microscopes and other related subjects. With a view to quality control and advice on standardization, free inspection facilities are being offered by the Central Scientific Instruments Organization (CSIO), Chandigarh.

As a result of these sustained efforts, a market survey would show that the quality and precision of many of the indigenous microscope mechanics compare favourably well with imported ones. Due to the lack of corresponding increase in the number of lens manufacturing units in the country, however, the indigenous microscope industry still remains mainly dependent on imports to meet its requirements of optics, i.e. objectives, eyepieces, condensers, prisms, reflectors, graticules, filters, etc. In the present days of acute foreign exchange difficulties, when the defence needs are to be first met on priority basis, this industry is often faced with a crisis due to this continued dependence on essential optical components.

The aim of the present paper is to show that there is a definite case for the early development of microscope optics industry in India, without any foreign collaboration, as the essential raw materials, machinery, components, product technology, production process and test equipment are already available in the country. Brief details of a pilot plant scheme for the manufacture of microscope optics are also given, with an enumeration of advantages that could be gained.

Raw materials

The work in respect of laying specifications for the materials and components needed in fabrication of optical and mathematical instruments

is already in hand (ISI Committee EDC 36 : 5).

The Central Glass & Ceramics Research Institute (CGCRI), Calcutta, is already producing nine principal types of optical glass which fulfil the major glass types required in respect of the optics of most microscopes[3]. If, however, any other special type of glass is needed, efforts can always be made for its development, and it is hoped, that this task can be accomplished much quickly, keeping in view the benefits of past experience at hand. The bulk production of optical glass may not pose a serious problem, as the quantity needed will not be large, and the expansion programme is already envisaged by CGCRI.

Most of the raw materials needed in optical glass working are also available in India. M/s Kilburn & Co. Ltd, Calcutta, are already producing diamond impregnated tools of good quality. Carborundum Universal Ltd, Madras, are scheduled to commence production of aloxite grains towards the second half of 1966 which would be suitable in processing glass. Grindwell Abrasives Ltd, Bombay and several other firms, are reported to be already in a position to meet other abrasive requirement needed for this industry.

The requirements of abrasive emery grain used for polishing purposes have also been already laid in ISI Specifications[4] which have been drafted with a view to utilize indigenous materials to the maximum extent, thus, permitting use of carborundum or synthetic emery in place of natural emery. Other miscellaneous materials like pitch, waxes, industrial solvents, sheet glass etc. are also available locally.

As regards a few scarce metallic materials not available presently in the country, efforts could be made for their substitution by aluminium. The National Chemical Laboratory, Poona can be called upon to develop suitable optical cements, pending which small imports could be allowed covering also a few other assorted items, like coating sources and materials, polaroid sheets, birefringent plates etc.

Machinery

Trepanning, roughing, fine grinding, polishing, edging, cementing and coating are some of the essential operations needed in making micro-lenses. Most of these jobs do not require very elaborate machinery. CSIO has already successfully designed and fabricated a pedal polisher. The design and fabrication of roughing and polishing machines needed for the purpose is in hand. This Organization is also equipped with a curve-generating, centering/edging machines, and a medium sized vacuum coating plant, which can serve immediate needs.

A few types of roughing and polishing machines are also being indigenously fabricated and marketed by a few firms like Prabhat Works, Delhi; Continental Engineering Co., Delhi; M/s G.C. Doss & Co., Indore; Harvin Optical Glass Industries, Hyderabad, etc. Glass trepanning machines are available from M/s Kilburn & Co. Ltd, Calcutta.

With the nucleus of glass working machines building units already established in the country, and with the active assistance of Hindustan Machine Tools Ltd, Bangalore and CSIO, it does not seem to be an insurmountable work. It may be stressed that the development of such machines in India will not only give impetus to the growth of micro-optics but will also accelerate creation of ancillary units producing photographic lenses, telescopes, survey instruments, etc.

Components

The Central Glass & Ceramics Research Institute is already supplying moulded blanks to suit micro-optics, and optical glass sheets of specified thicknesses. This Institute is also engaged in the development of suitable filter glasses. Test spheres/plates accurate to within $\lambda/4$ to $\lambda/10$ are available from Subramonia Scientific Instruments, Attingal, as also CSIO. This Instrument Research Laboratory Ltd, Calcutta, are understood to have perfected a process for etching of graticules and plan to produce them shortly (Mukherjee, S.K., personal communication). Work is also planned to be pursued at CSIO on the development of a process for engraving and etching of graticules, and investigations on celluloid coated packing of fragile optical components. Shri Gopal Silver and Gold Plating Industries, Ludhiana, offer assistance in production of suitable size reflectors.

Product Technology

CSIO has already worked out some optical designs for microscope objectives and eyepieces, based on the glasses available from CGCRI. The optical design and computation work is also being actively pursued for several years by the Ordnance Factory, Dehra Dun, who are actually, producing optics to meet defence needs. National Instruments Ltd, Calcutta; Indian Institutes of Technology at Delhi and Madras, and a few Universities in India, as also a few private firms like Andhra Scientific Works, Masulipatam, M/s P. C. Banerjee, Calcutta; Instruments Research Laboratory, Calcutta etc., are also engaged in similar pursuits and offer training courses in applied optics.

It is thus evident that the necessary technical know-how in respect of microscope optics is fairly well known in the country, at least on a laboratory scale, but may need to be perfected at large scale production stage. Furthermore, with the background already formed, assimilation of information from literature, and critical examination of imported products, even if a few more designs are needed, these can always be developed in a short time from indigenous raw materials.

Production process

Production of precision optics is more an art than elaborate complicated scientific process which needs to be evolved. Much depends on the skill, patience and mental attitude of the workman. True, we lack very much presently technicians of such a calibre, proficient in optical glass working trade. But several organizations in the country like Small Industries Service Institute, Delhi, CSIO, are very much alive to the problem and taking suitable steps in this direction.

It may be stressed here, however, that coaching in research/academic institutions alone is not sufficient to engender full confidence of production techniques in the minds of trainees, and the national undertakings. The Ordnance Factory, Dehra Dun; National Instruments Ltd, Calcutta; Government Precision Instrument Factory, U.P., Lucknow; and other big industrial units, like Andhra Scientific Co. Ltd, Masulipatam; Purban Pvt. Ltd Calcutta; Towa Optics (India) Pvt. Ltd, Delhi etc., who are already producing optics in the country should be persuaded to give them in-plant training. Though it is true, that when it is more a question of craftsmanship than terse operations difficult to copy out, no individual firm considers it desirable to take risks — which holds good even for advanced countries in the world — lest it may mean divulging of secrets in larger

interests of the country, these doubts should be temporarily shelved. Furthermore, on successful completion of training, this cadre of optical workers can itself be of help to these firms in meeting the personal requirement of their future expansion programmes and streamlining production.

Testing

For satisfactory consistent performance of finished product, components should be produced to within specified tolerance limits, necessitating critical testing at each stage during their manufacture.

For quality control and maintenance of standards of optical components, CSIO Optics Laboratories are already equipped with essential test equipment like angle dekkor, autocollimators, refractometer, precision goniometer, monochromators, apertometer etc. A Clévè test bench is expected to be set up shortly. For rapid check on curvature, a series of ring spherometers, and an interferometric viewing device for evaluating optical surface accuracy, have been designed and fabricated. For precise measurement of radii of curvature of micro-lenses, development of an optical spherometer is in progress. Some of the measuring tools, like micrometers, dial gauges, calipers, etc. are also available which can as well be supplemented in future.

Facilities for optical testing are also available in several other institutions, prominent among them being National Test House, Calcutta, and National Physical Laboratory, New Delhi.

It is thus seen that our basic needs for inspection of optics can generally be met with. At graduate and post-graduate levels, as optical measurements are included in curriculum of most Universities in India, there is also not so much of paucity of personnel, for this job.

Pilot plant scheme

For reasons laid above, regarding feasibility of producing micro-optics at home, CSIO has proposed a pilot plant scheme. In the first phase of the project, it is contemplated to produce eye lenses which comparatively requires less skill. After the initial training is over, selected trainees can be put to produce microscope objectives. Capital grant needed is about Rs 1.5 lakhs with Rs 28,000 as recurring expenses excluding wages of the staff and overhead charges, like power, maintenance of buildings, etc. Production is expected to be to the tune of about 100 lenses per day, to an accuracy within five fringes of radius of curvature and one fringe astigmatism on each surface, yielding a capacity of 28,300 lenses per annum. Net annual sale value of lenses produced is estimated to be Rs 1.25 lakhs approximately.

If the scheme is effected into operation, it can lead ultimately to following advantages :

(i) Production of micro-optics in India of a quality comparable to imported components, thus, saving sizable foreign exchange and creating simultaneously avenues of fresh employment.

(ii) Training of technicians in techniques of mass production of optical components and thus creating a cadre of optical glass workers which are in very much short supply in the country.

(iii) By serving as a model for industrialists, it will give a fillip to the development of other optical components manufacturing

workshops, which in turn, will lead to the establishment of optically based precise instruments industries.

(iv) Acceleration to the production of grinding and polishing in India.

(v) Rationalization of optical components/instruments and elimination of difficulties caused due to importing products from various countries based on their national or company standards.

(vi) Gradual evolution of Indian Standard Specifications on the subject, drafted with a purpose to utilize indigenously available material to the maximum extent.

(vii) Development of designs based on optical glasses produced at CGCRI.

(viii) Elimination of perpetual dependence on essential defence items and create consciousness to effect improvements in our design and production technology.

(ix) Elimination of diversification in basic systems of unit, in vogue at present, consequent due to importing optical components from various countries.

Acknowledgement

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Industrial Instruments & Components and Possibility of their Manufacture in India

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In view of the recent crisis and acute foreign exchange shortage it has become necessary to re-think about the import of certain industrial components and spares and consider manufacture of these items in India. It will not be very difficult to manufacture these items in India if there is a close cooperation and proper feed back of information between the research organizations and manufacturers and industries which are consuming these products.

Manufacture of these components and spares does not require much special skill and can be done with the technical know-how and raw materials available indigenously. In the case of products where international patent right and trade secrets are involved, foreign collaboration may be sought for.

Below are given a few products and spares which are imported all along for the running and maintenance of our instruments and controls which can be manufactured in India without much difficulty.

Thermocouple wires

Standard size base metal. Iron-constantan and chromel-alumel and iron-copper constantan thermocouple wires — 12 S.W.G. and 16 S.W.G.— are required in large quantities in various laboratories and industries for measurement of temperatures up to 1000°C. and there should not be much difficulty in manufacturing these wires in India.

Platinum & platinum-rhodium wires. These wires are being processed by a few concerns in India but some more research and investigation is necessary in this regard. After using we have found that these processed wires are brittle and not properly heat-treated and do not conform to the standard temperature/millivolt characteristics. We are spending about £ 5000 a year on foreign exchange in importing these wires in our Plant alone.

Surface pyrometer strips

These are made of chromel and alumel strips with welded joints. Such simple items should not be imported any further.

Compensating cables

Similarly compensating cables for different types of thermocouples should be manufactured in India and there is a great demand for it.

Resistance thermometer bulbs

These are normally non-inductively wound resistance elements made of nickel wire and platinum wires. We spend a large amount of foreign exchange for importing these resistance bulbs. I feel these bulbs should be made in India by the instrument manufacturers in this country.

Thermocouple sheath

There is also a great demand for metallic sheath of standard sizes which can stand a temperature of 1350°C. and which can be used in oxidizing or reducing atmosphere. We are importing lot of these Kanthal sheaths for thermocouples. Research organizations of our country should examine the possibility of making in India these Kanthal sheaths or develop suitable substitute capable of withstanding this temperature and furnace atmosphere.

Refractory sheath

For platinum and platinum-rhodium thermocouple we are using recrystallized alumina sheath. All these refractory sheaths are imported and there is a huge consumption of these sheaths in India. Our refractory manufacturing concerns in India should take up the manufacture of these sheaths in India with the help of research laboratories.

Properties of recrystallized alumina. It contains very high purity of alumina not less than 99.7 per cent. Due to its low silica content, it is comparatively inert, even at a high temperature and reducing atmospheres and flux attack. It is extremely hard, and has high mechanical strength and resistance to abrasion. It has high thermal conductivity and good electrical resistivity at high temperature.

Chemical analysis

99.7%	—	Al_2O_3
Recommended max. service temp.	—	1960°C.
Thermal expansion	—	8.8×10^{-6} cm./cm./ °C.
Thermal conductivity	—	35 B.t.u./hr/sq.ft (°F.) at 1300°C.
Density	—	not less than 3.72 gm./cc.

Inert in hydrogen and carbonaceous atmosphere
Offers very high resistance to alkaline and other fluxes
Resistance to thermal shock : moderate

Temp-tips

This is a cartridge type unit which can be used only once for taking steel bath temperature. The whole unit can be manufactured in India with foreign collaboration. Details of its construction and samples can be obtained from us if somebody is really interested in its manufacture. We are using a number of them in one year and this costs our plant Rs 55,000 in foreign exchange. The total demand for this item in India will be very large indeed.

Radiation pyrometer

In all high temperature measurements and in places where thermocouples cannot be used radiation pyrometers are extensively used and these

are all imported. The optical system is not difficult to make and in fact we are making many optical instruments in our country. The sensing element, which is normally a thermopile or a photocell should not be a difficult item for our research laboratories to investigate and find out.

Optical pyrometer

Most of the components of the optical pyrometer can be manufactured in India. We are making sensitive moving coil instruments and filament lamps in our country.

Our research organizations can find out a suitable filament which will give us the standard temperature/intensity curve or we can form our own standard.

Audco valves

Small size Audco valves are manufactured in India by Messrs Larsen & Toubro Ltd. But this does not always suit industries' need. Bigger size Audco valves, with pneumatic operation, should be manufactured in India. This could be done by Larsen & Toubro with the help of research organizations.

Metallic diaphragms, bourdon tube, bellows

Pressure gauges of different kinds are manufactured in India by various firms. But high pressure bourdon tubes, metallic diaphragms and bellows are not manufactured in India. The feasibility of manufacturing these items in India should also be examined.

Small motors

Small shaded pole and split phase reversible motors are needed in large quantity for instruments and controls. Small motors are manufactured in India but these are not very suitable for instrument purpose. The motors manufacturers may start manufacturing small motors like Sangamo motors etc. for which there is a big market

Electronic temperature recorder

Millivolt type temperature indicating and recording instruments are being manufactured in India successfully. These are inherently slow moving and low power instruments.

Null balance type electronic instruments are extensively used where faster operation and more power is necessary and till today we are importing these instruments from abroad. Almost all electronic components that are required for such instruments are manufactured in India and there is no reason why these instruments cannot be manufactured in India.

Oxygen equipment

In all the steel plants large number of scarfing torches are being used for deseaming the blooms, slabs and billets. These scarfing torches are all imported each costing about Rs 4000.

The C-51 scarfing torch is a proprietary item of British Oxygen Co. The Indian Oxygen Co., their representative in India, should start manufacturing this torch in India. We have noticed that 90 per cent of the components can be locally made and there should not be much difficulty in manufacturing these torches in India. The Indian Oxygen Co. is already manufacturing some cutting torches and blow pipes in India.

For cutting and scarfing, the Indian Oxygen Co. may be advised to manufacture suitable nozzles which can be used with coke oven gas considering the scarcity of acetylene.

Instruments for Measurement and Control in Textiles and Related Fields

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The export value of India's textiles is far less than the foreign exchange spent on imports by way of raw materials and machinery. A successful plan to step up our textile exports would be vitally dependent on the economic upgrading of quality and productivity in textile mills. The increasing use of instrumentation and process control would be one of the keys to this doorway. The intake of fresh equipment needed for this purpose would be at the very least Rs 1 lakh for each mill, provided Indian built instruments are available. At a very conservative estimate, the cost would go up by at least three times if we were to import these instruments. The exchange gap for 500 mills would thus be of the order of Rs 10 crores, which is not spectacular compared to the amount of fibre we import every year, nevertheless enough to make us look seriously to the possibilities of making textile testing and process control instruments in the country. If we are successful in this regard, the equipment so built would itself have a modest export potential.

Ideally, each of the several hundred textile mills in India should be equipped with a test house for carrying out regular measurements on the properties of raw materials, intermediates and finished products. In the present context, such a test house would need fairly sophisticated and generally electronic instruments. In processing operations such as bleaching, dyeing and finishing, and in certain of the spinning and weaving operations the process of quality control from the test house can often be short-circuited by the use of automatic process controls to regulate machines. Process control in the dye-house is attained through the regulation of familiar parameters such as temperature, level, flow rate, concentration or pH, roller speeds and so on. The necessary tools are not special to the textile industry. Laboratory testing instruments for textiles are also only superficially different from those employed in many other respects. Thus every textile mill is a potential customer for electronic hardware worth a few lakhs of rupees of which a small slice will go for measuring instruments and the rest for process control. Some of the basic hardware could also be used by many other industries such as paper, plastics, leather, dyes and auxiliaries and so on. Today the utility of testing and process control is being increasingly realized by textile mills, partly as a result of interaction with the many research organizations which now cater to them. This need is only very partially satisfied because of the lack of an indigenous industry which makes the requisite tools of the trade in India and offers adequate service facilities to keep them going. The present paper seeks to highlight some specific instrumentation needs of textiles and the country's state of self-sufficiency in producing these. It is hoped that this study might be

of some interest in relation to the instruments which are now freely available, namely water baths and ovens, stabilized power supplies and oscilloscopes, students' spectrometers and spectroscopes and so on.

Testing instruments

Testing of fibres. Since fibres account for nearly half the cost of finished textiles it is of the utmost importance to quantize those fibre properties which govern the correct choice of fibre. In the case of man-made and synthetic fibres there is reasonable uniformity in fibre properties from fibre to fibre and from batch to batch. However, natural fibres such as cotton, wool or jute are extremely variable in respect of their length, linear density, strength, contamination by impurities, moisture content and so on. Devices to measure these properties are a must in the mill test house. Moreover, the volume of testing required for practical quality control is so great that the utmost automation and speed are called for in the test methods used.

Taking fibre length and its variability, it is possible to fractionate fibres into different length groups by means of a set of parallel combs. Instruments based on this principle and suited for cotton fibres are now being made in this country. However, the test is too tedious and time-consuming to make a practical impact on the day-to-day use of cotton in a mill. Rapid electronic sorting of different length groups is the only answer to the problem of speed. Instruments for this purpose are available from abroad at prohibitive cost. Our research should be centred on replacing such instruments by indigenous designs. ATIRA has already made a step in this drection. However, a great deal of further effort is required before we have a thoroughly satisfactory tool.

Another property of prime importance to the technologist is some measure of the cross-sectional size of the fibre. This could be either diameter for round fibres like wool or linear density for fibres of irregular cross-section like cotton or rayon. The diameter is of the order of microns and the linear density of the order of micrograms per centimetre. Thus measurements on individual fibres are ruled out. Bulk tests, based on the principle of the resistance of porous plugs to air-flow, have provided a partial answer to the problem of high speed testing of cross-sectional size. ATIRA has developed an instrument of this sort which is suitable for finding the linear density of cottons. The same principle can easily be adapted to other fibres like wool. Coming to synthetic fibres and filaments, the measurement of linear density of individual strands is required in quality control. This is done electronically by subjecting a length of running strand to tension and finding out the frequency of transverse vibrations. The design of an indigenous 'vibroscope', as it is called, will be of great use to our manufacturers of man-made fibres.

The strength of fibres has a direct bearing on the strength of yarns and fabrics. On account of the great variability in individual fibre strength, it is the practice to break a bundle of parallel fibres and express the breaking strength in terms of linear density of the bundle. Such fibre strength testers are simple in construction and pose no problems in regard to imported components. It is regrettable that they are not made in our country.

Cottons contain soil, broken leaves and seeds and other contaminants which are in general called 'trash'. The trash content varies widely with cottons. Knowledge of this content is obtained by using an instrument called the Trash Analyser which can be easily built from indigenous components. Research should be directed towards developing this very useful instrument in the country.

Hydrophilic fibres like cellulosics and wool contain varying amounts of moisture which can be measured with the aid of an oven and a chemical balance. Such tests take time. Electronic moisture meters are capable of nearly the same accuracy and are far more rapid in their working. It is heartening that Indian research laboratories have offered suitable moisture meters to the textile industry. Some of these are sophisticated enough to be used in further applications such as automatic moisture control in yarn and cloth.

Testing of yarns. A universally practised test on yarns is the measurement of 'count' or average linear density. This is done by wrapping off a precisely known length of yarn and weighing it. The weight is usually expressed on a reciprocal scale called the 'count'. Wrap reels and count balances involve next to no sophistication by way of design principles. Wrap reels are now made in India. Yet to this date many continue to be imported.

A length of yarn which is wound for determining the count is called a 'lea'. A second important parameter for quality control is the strength of this lea, which is measured on a tensile tester based on the pendulum principle. The design of a lea strength tester is straightforward. Nevertheless its production in the country amounts to no more than a trickle.

While the measurement of lea strength is a first step towards control of yarn quality, it is not very informative in regard to the frequency of weak places in the yarn which might break during various stages of conversion to cloth. High speed automatic tensile testers for single strands provide the necessary answer. This is an area where sophisticated engineering research is called for. A still more refined effort would be to make such testers autographic so that they can record the entire load-extension curve of the strand. Instruments in this category would be useful not only in textiles, but in all contexts of stress-strain testing.

The diameter and linear density of a yarn vary continuously along the length. Part of this irregularity is unavoidable even with the best of processing machines and raw material. Much more than the theoretical minimum irregularity is however present in actual yarns, particularly by way of sudden imperfections such as thick and thin places. The first step towards reducing irregularity is to measure and analyse it. Modern instruments for measuring irregularity are based on two principles: (a) 'weighing' the yarn by capacitive principles or (b) 'seeing' the yarn by photoelectric methods. These alternatives possess advantages and disadvantages of their own. The development of both capacitive and photoelectric irregularity testers should be greatly encouraged in order to improve the regularity of Indian yarns. A general purpose instrument of the former category and an instrument for jute in the latter are now available in the country. These instruments do not possess the versatility and sophistication which are offered by the best foreign designs. Further research towards improving our present models would be of great use.

Other quality control tests on yarn are the measurement of twist and the wrapping of yarn on black boards to grade it visually. The simple gadgets for making these tests are now being produced in the country.

Testing of cloth. Common tests on cloth include nature of weave, the number of interlacing threads per decimetre and the 'count' of the strands. The cloth construction can be determined with a low power magnifier equipped with distance markers. Such 'pick glasses' as they are called are still not freely made in India. The durability of cloth is

judged by measurements of tensile strength, tearing strength and resistance to abrasion. Sometimes bursting strength under pressure is also measured. Tensile and tear strength testers for cloth are usually based on the pendulum principle and pose no problems of manufacture. Indigenous production of these machines is growing.

Nowadays considerable interest centres around 'easy care' garments which do not wrinkle when they are worn and when they are washed. Gadgets for the rough and ready measurement of wrinkle recovery are quite easy to construct. They are also being produced in the country.

A class of more sophisticated measurements on cloth would be of optical properties such as gloss, colour, fluorescence with whitening agents and so on. Some instruments for these purposes have been designed in ATIRA. However, there is need for multipurpose spectrophotometers and colour meters which can be of use not only in the textile trade, but in a whole host of other industries as well, such as dyes, paints, plastics, pharmaceuticals and so on.

Process control instruments

General scope. As a rule, the textile machinery which we buy today from abroad incorporates sophisticated automatic controls. These devices are mostly lacking in the machines which are produced in India today, as well as in the older machines which will continue to be used for several years by our mills. Process control units can be designed as adjuncts which will fit on to existing machines and materially improve their performance. A review is given below of some of the important areas where this can be done, but is now being only marginally done.

Auto-levelling. The production of yarn is a sequence in which large fibre masses are broken down, individualized, and organized into long strands of ever decreasing thickness and increasing twist. At various points in this sequence the material is collected, mixed and fed into subsequent machines. Today the trend is to minimize this collection and mixing because of the unnecessary handling of materials involved. This can only be done if the output of each machine is adequately and automatically controlled. Control is particularly required in one all-important respect, namely the regularity of linear density along the length of the strand. The time-honoured method of improving regularity is to put a number of strands together before attenuating them. This process is repeated a few times. 'Doubling and drafting' are useful up to a point; but they slow down the process and the drafting introduces irregularities of its own. Modern electronic process control offers the promise of minimizing doubling and drafting. The principle is to meter continuously the amount of outgoing material by a suitable sensing head, compare the amount with a chosen reference and use the difference or error signal to take corrective action on the rate of collection or rate of input of material. This classical application of servomechanisms is called 'auto-levelling' in the textile industry. It can be applied at several points in the earlier stages of spinning. At the spindle point it becomes prohibitively costly on account of the large number of independent units required. Autolevellers at points of suitable convergence are available from abroad, provided the large sums of foreign exchange can be found! Work is now going on towards developing suitable designs in India. However, considerable amplification of this effort is necessary so that something worthwhile can be quickly achieved.

Fault detection and correction. As remarked earlier, spun yarns contain irregularly occurring imperfections such as thick and thin places and bits of foreign matter. In order to eliminate these, electronic fault detection is resorted to when the yarns are transferred from bobbins at high speed into larger packages. The detector (usually photoelectric) breaks the yarn around an outstanding fault and knots the broken ends as neatly as the most skilful hands can do; but far faster. Another type of fault which occurs in groups of parallel moving threads is the breakage of one in the multitude. Manual inspection and remedial action causes los sof time as well as damages. Pneumatic, electrical or electronic detectors can help considerably in reducing these.

Dimensional control of cloth. Cloth tends to shrink in width during chemical processing. Devices called 'stenters' are used to keep the width at the desired level. Nevertheless, the stretch given by the stenter fluctuates at times beyond permissible tolerances. Photoelectric detectors are almost invariably used in modern processing machinery in order to provide automatic control of stretch. A more difficult control problem is posed by certain cloth constructions in which the threads in the weft direction tend to curve considerably. Sophisticated control devices called 'weft straightners' are now available, though quite expensive. Fortunately, not every mill needs them.

Moisture control. In operations such as dyeing and bleaching, the cloth is impregnated with aqueous solutions of various reagents. Afterwards the textile has to be dried adequately, but not over-dried. Whatever the drying system used, its temperature fluctuates from time to time and so does the amount of moisture finally held in the textile. Controlled drying can be achieved if the moisture content of the cloth when it emerges from the drying range is metered and the speed of passage of the textile through the drying system so regulated that the moisture is kept at the desired level. The measurement of moisture can be done in a variety of ways; such as from the change in capacity of a condenser through which the cloth is running or from the static charge generated on an electrode against which the material rubs. Many varieties of moisture controller are now available. One or two designs have also been developed in India, but their commercial use is not widespread.

Process control in the dye-house. Apart from some of the areas described above, the processes of bleaching, dyeing and finishing of textiles can be improved in several respects by the judicious use of automatic control. Liquid levels and temperatures, concentrations of reactants, the *p*H of a system and similar parameters tend to fluctuate or decay steadily when large lengths of cloth are passed through the liquid. All these fluctuations can be controlled very closely by the use of the classical tools of the trade such as resistance thermometers, level sensing electrodes, flowmeters, diaphragm valves and self-balancing potentiometers. Thus it becomes possible to achieve a more precise input-output relationship in the dye-house and effect economies in the consumption of dyes, chemicals and auxiliaries.

Plan for growth of instrumentation and control in textiles

The account given above would make it clear that there is a wide and diversified field of application of measurement and control in textiles. Not many mills are even reasonably equipped with testing laboratories or process control devices. What equipment there is has been almost always imported. The achievement of relative self-sufficiency in this respect is a most

significant challenge. What are the requirements for meeting this challenge? Who should be the prime organizers for the many-pronged effort which is entailed?

The first exercise is an appraisal of priorities in this field and the drawing up of a phased plan of research, development and manufacture. In this exercise it will be possible to spell out which of the items can be manufactured straight away on the basis of available knowledge and without prejudice to patent rights. The quality and quantity of research effort required for other items can also be clearly perceived. One can also proceed to think of the organizations which can best undertake this effort. A study group drawn up from the textile industry and textile research laboratories on the one hand as well as from the instrument manufacturing industry and instrument laboratories on the other seems well fitted to undertake this appraisal on behalf of CSIR. It will offer a plan of research and development which is based on (i) the importance of the item in improving quality or productivity, (ii) anticipated complexities in design and manufacture and (iii) the foreign exchange involvement for components.

Assuming that development work is framed out to various institutions on the basis of such a plan, the highest priority should be attached to evolving instruments and machines which are as free of imported components as possible. Nevertheless, it is no use slurring over the fact that there will continue to be an inevitable residuum of foreign exchange requirements for such an effort. This requirement will be in terms of a number of instrument components which will not be required in large enough numbers to warrant their manufacture in India. At present the designer faces vexatious delays in securing even the simplest of such components. Typical instances, graduated according to decreasing price, are servomotors, photomultipliers, phototubes, relays, polaroids and straight filament lamps ! The last named item costs Rs 6. The author's laboratory has been vainly trying to import it for nearly 3 years. The bulk of such stock-in-trade items needed for making new instruments would have to continue to be imported until the demand in the country takes on dimensions of interest to an entrepreneur. At the moment the denial of foreign exchange for these components presents us with two self-defeating phenomena: (i) the entire instrument being imported by users on their export promotion quota and (ii) laboratories expending their major research effort on programming how to get a few pounds or dollars !

When a prototype model has been developed in a textile research laboratory or elsewhere, it can be tried out intensively in selected mills. Suggestions for improvement can be fed back until a prototype is evolved which is suitable for bulk manufacture. From this point the NRDC should be able to take over and assure bulk manufacture, provided the foreign exchange equation does not loom up in an unsolvable guise.

Geophysical Instrumentation

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The present position of Geophysical Instruments in India is assessed. With a review of the available resources for geophysical instrumentation in the country, the future trends of requirement and the expenditure in foreign countries involved, it is recommended that manufacture and development of geophysical instruments and accessories in the country be taken up with all seriousness.

Geophysical Instruments are being increasingly employed in India by a number of organizations over the last 15 or 20 years. These instruments, with the exception of a few only, have been imported from the UK, USA, Germany, USSR, and other countries. The object of this paper is to examine the present position and estimate the future trends to see if the state of the art in the country requires that we should make serious efforts to manufacture the instruments we need, or continue to be dependent on other countries for most of our geophysical instruments and apparatus as we are at present. The instrument industry, like many other industries in India, has not grown as one would have liked it to grow over the eighteen years since independence, and it is the object of this paper to see if there is something that could be done in this regard so far as geophysical instrumentation is concerned.

Present position

There are at least 15 organizations in India employing geophysical instruments for exploration, research, teaching, earth studies and the like, as listed below:

1. Oil and Natural Gas Commission, Dehra Dun
2. Geological Survey of India, Calcutta
3. National Geophysical Research Institute, Hyderabad
4. Survey of India, Dehra Dun
5. India Meteorological Department, Delhi
6. Central Water and Power Research Station, Poona
7. Tata Institute of Fundamental Research, Bombay
8. Institute of Physics, Ahmedabad
9. Osmania University, Hyderabad
10. Banaras Hindu University, Varanasi
11. Indian Institute of Technology, Kharagpur
12. Andhra University, Waltair
13. Indian School of Mines and Applied Geology, Dhanbad

14. Madras University, Madras
15. School of Research and Training in Earthquake Engineering, Roorkee

The types of geophysical instruments used by these organizations vary from the earth resistivity measuring apparatus up to the most complex and sophisticated instruments like the reflection seismographs. But a broad classification may be given as follows:

Magnetic Instruments

1. Schmidt type Magnetic Variometers
2. Torsion Magnetometers
3. Proton Precision Magnetometers
4. Observatory and laboratory instruments for magnetic measurements

Electrical and Electromagnetic Instruments

1. Earth Resistivity and Spontaneous Polarization measuring apparatus
2. Electrical Electromagnetic Well Logging Instruments
3. Ground Electromagnetic Prospecting Instruments

Gravimetric Instruments

1. Gravity Meters
2. Torsion Balance (This is rather obsolete now.)

Seismic Instruments

1. Refraction and Reflection Seismographs
2. Seismological Observatory Apparatus
3. Seismic Data Processing Equipment

For the operation, repair and maintenance of these instruments many consumables, spares, and accessories are used. Seismic shot hole drills and accessories, electronic test, measuring and recording apparatus, cables and photo sensitive material are only a few of the costliest items among literally hundreds of other things, that are being increasingly required.

One could not hazard an estimate of the up-to-date cost of the import of the above items without fear of underestimation. Table 1 gives a break up of the imports estimated from available information.

Table 1—Foreign exchange expenditure on geophysical instruments

(Rs lakhs)

	Total imports up-to-date	Import over past five years	Likely import during Fourth Five-Year Plan
1. Magnetic prospecting, observatory and laboratory instruments	9.6	2.2	2.5
2. Electrical, electromagnetic and electrologging	55.6	30.8	81.6
3. Gravimetric	13.6	2.5	2.5
4. Seismic prospecting and Seismological observatory	59.7	30.8	72.0
TOTAL	138.5	66.3	158.6

Table 1 indicates the large volume of import of geophysical instruments and accessories that have been made in the past five years and also that which is proposed for import during the Fourth Five-Year Plan. It will be noticed that nearly 50 per cent of the imports have taken place during the last five years and that more than all the imports made so far is envisaged during the Fourth Five-Year Plan.

It is true that all the requirements of geophysical instruments for the country cannot be met from indigenous sources. In fact there is no organization in the country manufacturing geophysical instruments and accessories for sale. Some organizations like the Geological Survey of India and Oil and Natural Gas Commission are making a few items and accessories mainly for their own use. This has been so because the volume of requirements perhaps did not attract the industry, or because of the lack of technical know-how in many fields of instrumentation so that we did not want to waste time trying to manufacture instruments which were readily available in foreign countries. The picture now is entirely different. The volume of requirements has increased by leaps and bounds, and with the poor foreign exchange position it has become necessary to examine what can be made in the country with the raw materials and technical know-how available at present, and also what can be manufactured by importing some items in the form of raw, or partly processed material, or components.

Instruments manufacture in India, either wholly out of indigenous resources or with some imported material

Among the class of instruments which can be manufactured in India we shall mention only those representative items which will indicate the nature of the presently available resources in the field. There would be more instruments of similar nature, and many more of those the manufacture of which calls for similar processes, materials and know-how, which could be made in the country.

Under the category of Magnetic Instruments we may consider the manufacture of the following:

1. Schmidt type Magnetic Variometers
2. Proton Precision Magnetometers
3. Fluxgate Magnetometers
4. Astatic Magnetometers for Laboratory Measurements
5. Field Compasses of various types

Among Electrical Instruments the following may be manufactured:

6. Electrical earth resistivity apparatus
7. Spontaneous polarization measuring instruments
8. Surface and borehole electromagnetic prospecting instruments
9. Certain types of Sondes and surface equipment for electrologging.

Of Seismic Instruments we may take:

10. Shallow Refraction Seismographs, single channel and multichannel recording types
11. Cables, geophones, and power supplies for Reflection Seismic work
12. Reflection Seismographs
13. Quartz Crystal controlled power supplies, timers etc.

Let us consider the magnetic instruments first. All raw materials required for making Schmidt type magnetometers are available in the country except the material for the magnet needles and good quality fused quartz for the knife edge and bearings. If only these raw materials are imported, it should be possible to make Schmidt type magnetometers. The other parts required are brass, bronze, copper and aluminium cast and machined parts, for the case and the stand, lenses, prisms and plates for the optical system with good quality marking or etching, timberwork parts for the stand and box etc. Optical system know-how is already available in the country as some organizations like the Ordnance Factory, Dehra Dun and National Instruments Factory, Calcutta and some other private firms are engaged in the making of survey instruments and the like. Good quality optical glass is being made in a pilot plant in the Central Glass and Ceramic Research Institute, Calcutta. The spirit levels requiring a sensitivity of the order of 30 sec. of arc per mm. of travel should not pose any particular problem as some firms in India are already making levels of the same order of sensitivity.

Proton magnetometers for the measurement of the total value of earth's field can be constructed from indigenous components excepting the relays required for switching the polarizing current in the coil. These relays also could be made by the Indian Telephone Industries, Bangalore, who are engaged in making many varieties of telephones circuit relays. In fact, the first entirely portable proton magnetometer in India was made in the Geophysical Division of the Geological Survey of India in 1963 almost entirely from indigenous components. Proton magnetometers have been made in the Ahmedabad Physical Laboratory, and in a Defence Research Laboratory also. Quartz crystals, required for the reference frequency, are being made by M/s Bharat Electronics who are also making all the types of transistors required. Other electronic components required for this are resistors, capacitors, small inductors, transformers, switches, meters etc., all of which are available from indigenous sources.

Fluxgate magnetometers can be made similarly by importing only the easily saturable strips of magnetic material; the rest of the electronic circuit components required are all available in the country.

Astatic magnetometers employing two small parallel magnets magnetized in opposite directions have been assembled in the Tata Institute of Fundamental Research, Bombay, and the know-how is available. Thin quartz fibres pulled from fused quartz rods have been successfully made and used in some laboratories in the country, of which the Magnetism Laboratory of the Indian Association for the Cultivation of Science, Calcutta is one.

Field compasses like Clino and Bruntom compasses can also be made (Clino compasses are being made already), and all such other instruments employing mainly a jewel-and-pivot mounted magnetic needle.

Electrical prospecting instruments of the simplest type are the earth resistivity and spontaneous polarization meters. These instruments involve potentiometers of good linearity and fixed wire wound resistors of good stability. Potentiometers having a linearity better than 0.5 per cent are being made for a number of years in the Geological Survey of India for the construction of earth resistivity and S. P. equipment for their own use. These potentiometers and fixed resistors use low temparature coefficient, high resistivity material like constantan for the resistance wires. Only this would be the imported item now, since moving coil meters are also available from indigenous sources. (Most of the moving coil meter makers are,

however, importing the essential components for assembling the meters, but the situation is going to improve when permanent magnet material and soft iron core material are manufactured in the country.)

For surface and borehole electromagnetic prospecting instruments the components required are mainly of those types employed in electronic and solid state circuitry, most of which are available in the country. The low power surface systems employing an oscillator to produce the primary field and a sensitive pick-up coil to pick-up and measure the resultant field make use of high saturation flux density and high permeability material which are not manufactured in the country. Highly ferromagnetic ferrites, or mumetal in the form of flat strips are to be imported for these instruments. These materials are quite cheap when compared to the cost of complete imported instruments. A number of such instruments have already been made in the Geological Survey of India mostly from indigenous material and components. The high power surface and borehole systems require, in addition to the above, an engine driven generator producing a low or medium audio frequency at a power level of 500 to 1,500 watts. At present engine driven multipole alternaters at these frequencies are not made in India, but the know-how appears to be available.

Sondes and surface equipment for electrologging require electronic components which are mostly available in the country. The items not available are servomotors, choppers, small synchronous motors and a few components which are capable of withstanding the high temperature conditions in a borehole. Servomotors and choppers are used for potentiometer type pen recorders and are essential circuit components for many kinds of loggers. If these components are imported, pen recorders for many other geophysical applications could also be made. The Research & Training Wing of the ONGC, Dehra Dun, assembled one set of surface equipment for electrical logging successfully a few years ago.

Shallow refraction seismic apparatus using only one signal channel and measuring successively the travel time of P waves between one fixed and another movable point either by means of a visual indicator like a cathode-ray oscilloscope or by an electronic timing device could be made in the country now. The photographic recording types could also be made by importing some special components like recording glavanometer, paper drive motor etc. Reflection seismic instruments could also be made by importing some other special components and raw materials like high magnetic permeability core material etc. Multichannel seismic land cables could be made in the country as is evident from the fact that one such cable was made in the Geophysics Directorate of the ONGC. Geophones for seismic reflection work also were made in the Geological Survey of India.

Many types of electronic power supplies are already being made in the country. It would be possible to make quartz crystal stabilized power supplies also for Seismological Observatory and such other applications. Electronic timers and control devices for these applications may be manufactured from indigenous materials and components.

The above is by no means a complete list of geophysical instruments and accessories that could be made in the country now either wholly from indigenous components and material of by using a certain proportion of imported items. If the manufacture of such instruments be taken up much of the imports now envisaged could be substituted by indigenous equipment, thus saving a large amount of foreign exchange every year. The proportion of saving is bound to grow as indigenous production would cause methods and processes to evolve so as to reduce imports further. Of the estimated

Rs 159 lakhs worth of foreign exchange expenditure on geophysical instruments envisaged by the country during the Fourth Five-Year Plan period, a saving amounting to 60 per cent of the total should be possible, if the remaining 40 per cent is spent mainly on components and raw material for the fabrication of instruments rather than on complete units. Moreover, in many instances the cost of indigenous production would be less than that of a corresponding imported item having an equivalent order of merit in performance, though the instrument might not be quite as good looking. There is no denying the fact that instruments now made in India do not at all compare well in their 'looks' and 'finish' with those we are accustomed to see abroad. But with some amount of care in the design and fabrication it is possible to make instruments which would compare very favourably with imported instruments so far as the performance and reliability are concerned. This is particularly true of electronic instruments.

Among the accessories for geophysical instruments, two items need special mention, viz. shot hole drills for seismic survey and photographic sensitive material for various types of recorders.

In seismic prospecting the shot hole drills used vary in their capacity from a few feet, in the case of manually driven systems, up to about 1000 ft in the case of power driven truck mounted drills. It is estimated that about Rs 130 lakhs worth of drills of these types have so far been imported and about Rs 90 lakhs worth of the same are to be imported during the Fourth Five-Year Plan period. Efforts to manufacture these drills in the country might be made along with the manufacture of accessories like drilling bits etc. The draw works, rotary tables etc., could perhaps be taken up in the Heavy Engineering Corporation and engines and pumps etc., could be taken up by firms already engaged in making such items. Since similar drills are useful for exploratory as well as production wells for water also, the manufacture of this item has a special significance.

Photographic papers and films of various sizes and grades are required for many types of recorders used in the field of geophysical measurements as well as many other fields. The manufacture of grades and sizes according to specific requirements in these fields may perhaps be taken up with advantage since certain types of photographic material are already being made in the country. The seismic prospecting instruments alone are estimated to be consuming about Rs 50,000 worth of photographic paper every year, and this is expected to increase three times by the end of the Fourth Plan. Since this would represent only a very small fraction of the total requirements of such photographic material, it appears reasonable for the country to manufacture the same.

Instruments which cannot be made immediately

There are, however, some instruments the perfection of which in comparable precision, performance, and reliability in our country would appear to take some time yet. This, in some case, might be attributed to the want of know-how, skill and good workmanship and, in others, to the nonavailability of special materials, components and facilities.

Under this class of geophysical instruments would come gravity meters, magnetic recording reflection seismographs, rubidium vapour magnetometers, observatory recording magnetometers, seismological instruments, high speed chart recorders, seismic data handling and computation equipment, airborne electromagnetic equipment, borehole seismic velocity logging instruments, aerial photographic equipment, torsion magnetometers, induced polarization apparatus and the like.

The gravity meter, for instance, requires exceptional skill and precision workmanship involving mechanical, optical and highly delicate quartz fibre work. The rubidium vapour magnetometer, on the other hand, requires special optical filters and polarizers in conjunction with highly stable electronic circuitry.

Summary and recommendations

Some instruments and accessories, therefore, can be made with little or no import and some others by importing a few important components or raw materials. The know-how for making these instruments are available in the country in a kind of scattered fashion, so that no single organization is in a position to take up the entire work on its own. In this context, the National Geophysical Research Institute, Hyderabad, and Central Scientific Instruments Organization, Chandigarh, could play a very important role. Production of prototype instruments not made in the country and the development of new instruments could be taken up, in a collaborative programme of work with other organizations also, where necessary. (The National Geophysical Research Institute, in particular, is being equipped with this end in view, and it is expected that the Institute will be able to produce a few prototypes of geophysical instruments before long.)

Production of these instruments can be taken up, after the prototypes have been thoroughly tested under field conditions in actual surveys either in pilot plants or in some production establishment, depending on the quantity of requirement. It is quite natural to expect that after some time it will be possible to produce good quality fieldworthy instruments of a few types in the country for export at competitive world market rates. That such a kind of development is entirely possible is shown by the example of the Electronics Division of the Atomic Energy Establishment Trombay, who are now manufacturing a large number of radiometric field and laboratory instruments which, even a few years ago, were all being imported.

The programmes of Geophysical work envisaged during the Fourth Five-Year Plan when compared with the work done during the second and third five-year plans clearly shows the trend of fast increasing geophysical activity in the country. In the field of exploration geophysics alone there has been a very big increase. While in 1955 there were hardly eight geophysical field parties around, the end of the Fourth Plan would see, if work goes on in accordance with the plans, as many as 150 field parties including two off-shore seismic parties, sixty land seismic parties and twenty-four gravity parties among others. If this venture is not to be made too costly for us in terms of expenditure in foreign countries we must now make efforts to manufacture geophysical instruments and accessories to the best utilization of our own resources and develop new instruments to the best of our abilities.

Acknowledgement

The author thanks Dr A. Roy, Dr P. V. Shankaranarayana, Shri G. Varadarajan, Shri H. K. Gupta and Shri B. P. Bhattacharya, Scientists, NGRI, for considerable help in the preparation of this review.

Importance of Instrumentation in River Valley Projects

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Since the beginning of planned development in India, the country's water resources have occupied an important role in the national Five-Year Plans. The emphasis has shifted still more favourably for the speedy development of water resources in view of the present emergency in the country. Self-sufficiency in food, which is foremost in our minds at the present time depends mainly on the availability of water for irrigation and production of electric power. To harness the waters flowing in our streams and rivulets for irrigation and power it is evident that giant schemes for the development of our river valleys need to be taken in hand. Considerable sums of money are spent in the execution of such projects. Every effort is, therefore, called for to bring about economy at each stage of execution.

The most obvious way to effect economy in a project is to use the materials of construction in an efficient way and have the means to indicate the behaviour of the structures involved. The intention of the author is to make a point here that the instrumentation in river valley projects serves these purposes effectively and there is a need to make a provision for the same for all our major structures.

Though the role of instrumentation in river valley projects begins right from their investigation stage when observations are necessary to determine the properties of rock mass in situ, it is intended to deal here only with that part of instrumentation which relates to the structural behaviour study of dams and other hydraulic structures such as tunnels and penstocks.

Objectives of instrumentation

The objectives of instrumentation are two-fold. The instruments embedded in, or installed at the surface of dams and other hydraulic structures keep a constant watch over their performance in service and indicate the distress spots which call for remedial measure. Thus, these instruments play an important role in checking the safety of the structure.

In addition to serving the purpose of telling the 'health' of the structure, the observations from the instruments form a cumulative record of the structural behaviour. The study of structural behaviour[1] provides an important aid in modifying purely theoretical treatment so as to include the effects of actual field conditions. Most hydraulic structures are built on rather conservative assumptions to provide for the 'unknowns' in the design. Observations from the instruments help reduce these 'unknowns' and place the future designs on a sounder footing. The modifications and refinements thus introduced in the designs result in structures wherein

the materials are used more efficiently and continuous safety of the structure is assured.

Nature of measurements and their purpose

In order to achieve the objectives of instrumentation as described above, it is of extreme importance that a systematic and complete plan of various observations or measurements must be prepared for obtaining as complete an information as is possible regarding the various internal or external, permanent or transient loads, influencing the structural behaviour of dam and its foundations, and regarding the factors indispensable to interpretation of the results of such measurements[2]. Measurements should be planned for the most important zones of the structure. Planning of measurements is made taking into consideration the results of the analytical and experimental (model) investigations, as also of the studies of the foundation and its specific problems the investigation of which is considered to be of interest at the time. Various types of measurements made on previously built similar structure can aid in planning the necessary types of measurements for obtaining the needed information. It is essential that the various measurements made on the structure should be so planned as to provide information not only of the individual components of structural action but also of the integrated structural performance of the structure and its foundations.

The nature of measurements and tests to be carried out on any structure will depend upon its dimensions, namely height, thickness, span to height ratio, different foundation conditions.

When working out a plan of observations, the cost of the equipment of the observing personnel, and of the processing of observed data and interpretation of the results should be considered in relation to the cost of the dam and its situation. Limitation of the cost of instrumentation in a structure may be a determining factor in deciding the types of measurements to be made in a given structure.

It is obvious that the methods of measurements, instruments, staff employed for observation and processing of observed data, and interpretation of results must be of a calibre needed to achieve useful results under a variety of conditions.

Concrete and masonry dams

For observations of concrete and stone masonry dams, a complete set of masurements is listed below. These measurements are grouped under three headings:

Measurements indicative of structural behaviour

(i) Dam displacements in relation to points on the ground

(ii) Dam displacements in relation to other points in the dam

(iii) Rotations

(iv) Stress

(v) Strain

(vi) Uplift in the body of the dam, i.e. pore pressures

(vii) Temperatures of the dam interior

(viii) Joint movements

(ix) Seepage (infiltration)

Measurements of external loading

(i) Hydrostatic pressure, i.e. measurement of reservoir and tailwater levels
(ii) Uplift pressure at the base of the dam
(iii) Reservoir and air temperatures
(iv) Rainfall
(v) Ice effects
(vi) Dynamic loads, i.e. earthquakes

Measurement of properties of the material of construction in laboratory required for processing of observed data

(i) Elastic and inelastic properties, i.e. Young's Modulus; Poisson's Ratio; Creep
(ii) Thermal properties, i.e. co-efficient of expansion
(iii) Autogenous growth

Earth dams

Measurements in earth dams differ from masonry and concrete dams because of the relatively greater deformability and higher permeability of earth masses (excluding plastic clay hearting). Strains and displacements in earth dams are, therefore, very much larger. Hence comparatively simple instruments can be used for measurement of strains and displacements. Also, due to the large cross-sectional areas and greater heterogeneity of earth, large number of instruments have to be installed in earth dams. Distribution of stress in earth dams is more complex and the design analysis is based on radical simplification of the stress pattern and shape of rupture planes. Consequently stress measurements require considerable judgment in interpretation. Seepage is of far greater significance as it can cause internal erosion as well as increase in pore pressures resulting in instability.

For observation of earth dams, the following measurements are usually undertaken :

(i) Internal and surface displacements
(ii) Strains
(iii) Stresses, i.e. contact pressures at rigid boundaries and total internal pressures
(iv) Pore pressures

Other structures

Earth retaining structures, tunnels and underground rock structures, acqueducts and bridges, power houses, opening such as galleries, sluices and shafts, conduits, spillway piers and other control structures can also be instrumented with a view to measure structural action in these and subsequently introduce refinements in their future designs.

Of the above, instrumentation of tunnels[3] and underground rock structures is of particular importance since substantial economies can be effected by appropriate measurements. Measurement of diametral changes with respect to time in tunnels is of fundamental importance. A knowledge of the displacement of linings and of the surrounding rock as a function of

time not only makes it possible to determine whether equilibrium will be reached or not, but can also be regarded as a valuable means of ascertaining the magnitude and distribution of the forces around a cavity.

Determination of the magnitude and direction of the residual or locked in stresses in rock is essential to develop adequate criteria for the design and construction of rock structures such as large excavations.

Instruments

Instruments necessary for observation of dams may be broadly classified in three categories : Optical, Mechanical and Electrical. The electrical type instruments include not only those instruments the working principle of which is based on the measurement of the electric properties of the elastic wire but also those in which a mechanical value, such as the natural frequency of a steel wire, is measured electrically.

With the exception of instruments, used in the geodetic methods of measuring displacements, which are common to concrete stone masonry and earth dams, other instruments are listed below :

For concrete and stone masonry dams

Stressmeters, strainmeters, jointmeters, tiltmeters, thermometers, porepressure cells and deflection measuring equipment.

On Indian projects so far Carlson type of the above instruments, with the exception of tiltmeters and deflection measuring equipment, have been used. Other brand names of the same instruments, though based on different principle, are the 'Maihak' and the 'Telemac'.

The Carlson elastic wire type instruments are based on the principles that electrical resistance in a steel wire varies directly with temperature as well as with tension. Carlson Strainmeter, Jointmeter, Stressmeter and Porepressure cell are shown in Figs. 1, 2, 3 & 4 respectively.

Maihak and Telemac meters, generally called transmitters, contain a steel wire prestressed to vibrate. It is excited to a damped natural vibration by an impulse from the receiver. With the change of length (strain), temperature, pressure or force of the medium to be measured the natural frequency of the measuring wire in the transmitter also changes. This change constitutes a precise measure of the pressure or force.

These instruments are described in detail in their respective manufacturer's catalogues and hence will not be repeated here.

For earth and earth-rock dams

Embankment type of piezometers, Foundation type of piezometers, Hydrostatic pressure indicators, Porus tube piezometers, Total pressure cells, Vertical movement device, Horizontal movement device, Foundation settlement base plate.

Almost all of the above instruments are described in detail in the United States Bureau of Reclamation's Earth Manual, 1963.

Examples of Indian dams instrumented

Nearly 30 dams and 6 'other structures' have so far been instrumented in India. A list of such structures, as is known to the author, is given in the Appendix. Of the dams instrumented for their structural behaviour study, the 740-ft high Bhakra Dam stands out. A brief report

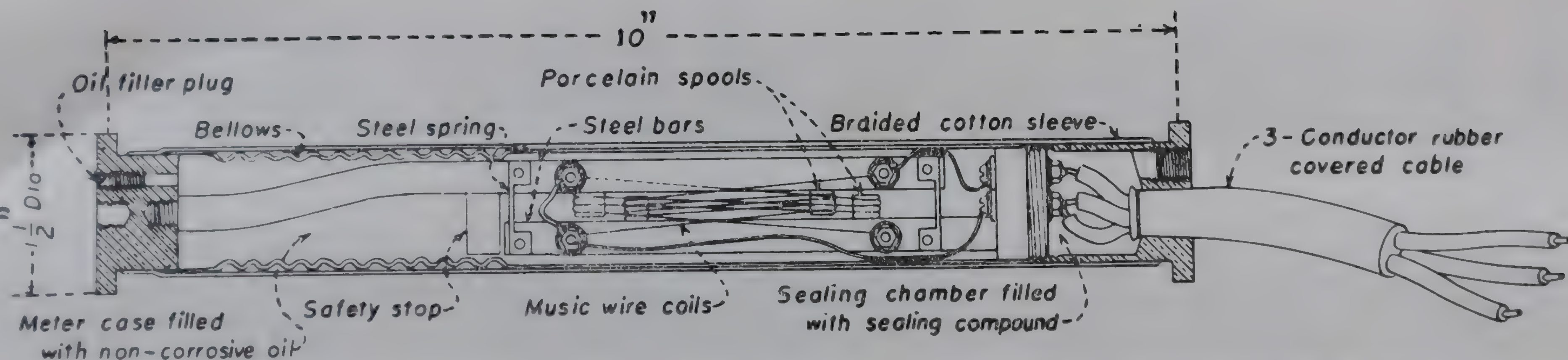

Fig. 1—Carlson Strainmeter (From "Measurement of Structural Action in Dams" by J. M. Raphael and R. W. Carlson)

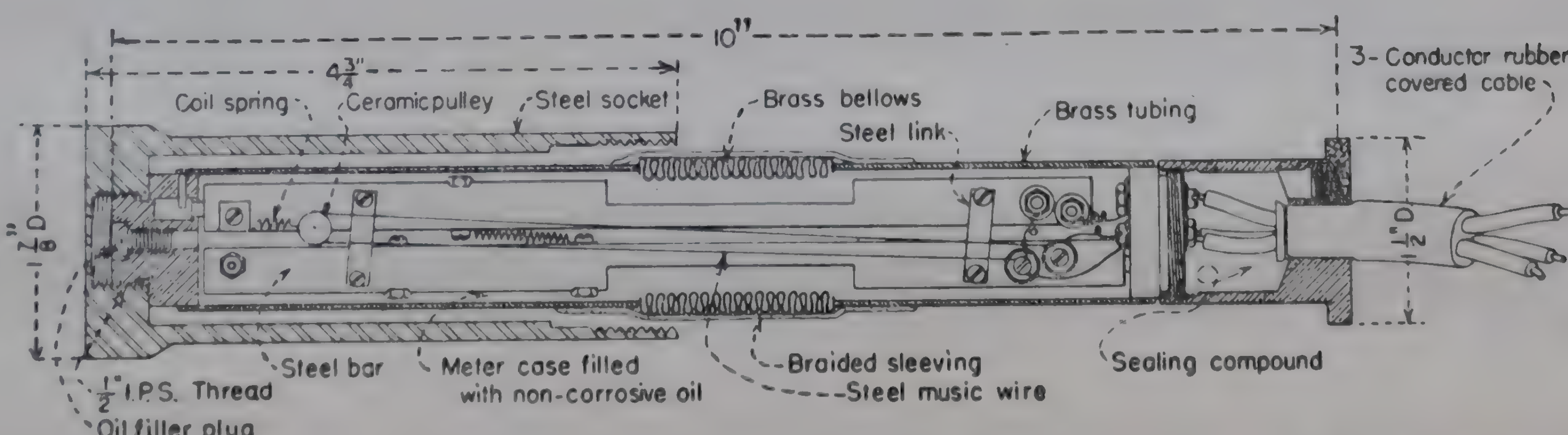

Fig. 2—Carlson Jointmeter (From "Measurement of Structural Action in Dams" by J. M. Raphael and R. W. Carlson)

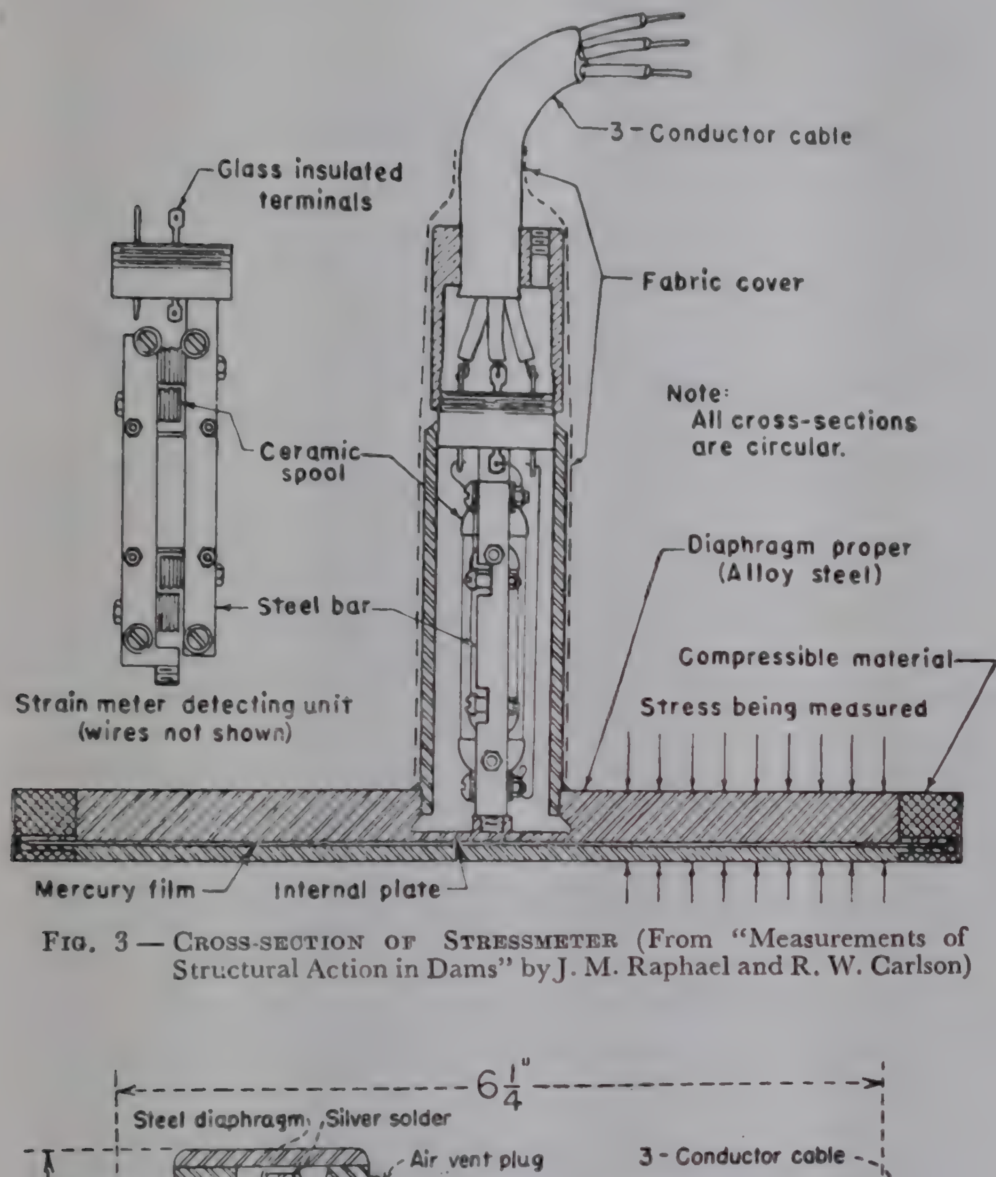

Fig. 3 — Cross-section of Stressmeter (From "Measurements of Structural Action in Dams" by J. M. Raphael and R. W. Carlson)

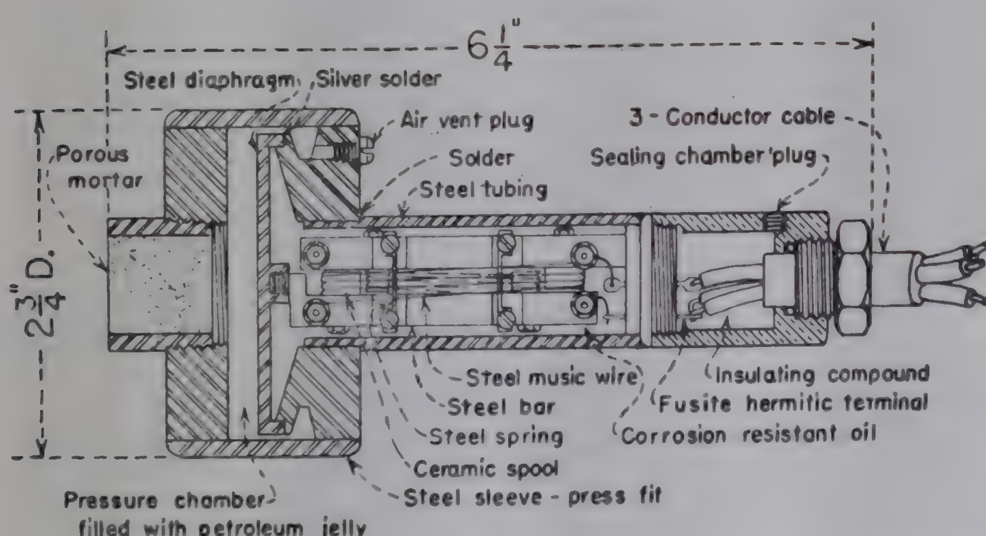

Fig. 4 — Carlson Porepressure Cell (From "Measurements of Structural Action in Dams" by J. M. Raphael and R. W. Carlson)

on its structural behaviour is given herein to indicate how the embedded instruments are helping to keep a watch over the safety of the dam.

As many as 694 Carlson type instruments are embedded into the body of Bhakra Dam. In addition, 8 lines of uplift pressure pipes have been provided. Seepage measurements are made at drainage holes. Three plnmb lines are installed for measuring dam deflections in the spillway

portion and in the non-overflow sections on either side. Measurements of dam displacements by geodetic methods are also undertaken.

The left power plant near the toe of Bhakra Dam[4] has been instrumented to measure uplift pressures and settlement of individual bays.

The latest review of the structures behaviour of Bhakra Dam[4] indicates that the observed uplift pressures have generally been below those assumed in design, with the exception of a few pipes. At one such location an additional drain hole was drilled to bring down the high value within the design criteria value. The low observed uplift pressures under the dam are indicative of an effective grout curtain and sound geological features at the site.

From the measurements of seepage, it is seen that it has been reducing with the falling reservoir level fairly consistently. Redrilling of holes is indicated for those which do not show any seepage, to ensure that they are not choked.

The observation of settlement in galleries indicates clearly the response of the foundations to the imposition and withdrawal of the reservoir load. A consistent trend to recovery from settlement with the falling reservoir is evident. From the observations of bench marks on the upstream and downstream rock ribs, it is seen that the valley undergoes adjustments with the filling and depletion of the reservoir.

Continuous time plots of the dam deflections at various observation levels is kept up-to-date to observe any sudden variation in deflection. Trend of recovery from deflected position with withdrawal of reservoir load is apparent and indicates behaviour consistent with expected performance.

The stressmeter data indicates that the stresses are within permissible limits. The data from the strainmeters are under processing and have not been reported in the review.

At Koyna Dam, a study of the dam deflections and variation in temperatures establishes a qualitative correlation between the two. It appears that temperature loading in concrete dams of moderate height far exceeds that from reservoir water.

Indigenous manufacture of instruments

There has been lately considerable emphasis on self-sufficiency and import-substitution in the country. However, the indigenous manufacture of measuring instruments has certain limitations in this regard. The primary consideration which must weigh with any indigenous manufacturer is the future demand of such instruments. The use of such instruments being a specialized one, the demand is naturally limited. However, where an allied industry is already existing, the manufacture of some of these instruments can be profitably taken up.

The future demand of instruments up to the end of Fourth Five-Year Plan is being assessed by a Committee[5] constituted by the Government of India to review the instrumentation already done in the country's river valley projects and to recommend a policy for effective implementation of measurement programmes in our hydraulic structures.

A criteria is proposed for judging the priority of a particular instrument for indigenuous manufacture. It is proposed that the instruments

which meet the following requirements should be given a high priority for indigenous manufacture :

(i) sizeable demand

(ii) the instrument is also used in other allied fields

(iii) the manufacture involves only extension of an existing skill

(iv) the imported components, if any, are of extremely small worth

(v) the dependability of the instrument

The author believes that a number of instrument would meet the above criteria and that a beginning should be made in the manufacture of such simple instruments, and other equipment necessary for their installation, as Micrometer Slide and Microscope for use in plumb lines, Carlson type Test Set, SR-4 gauges, Dial gauges, Bourdon gauges, PYNC tubing for piezometers.

It was intended to append complete specification and drawings of some of the above high-priority recommended instruments but it is regretted that these could not be made ready for the timely submission of this paper. The details may, however, be had from the Instrumentation Cell of the Central Water & Power Commission.

Conclusion

The instrumentation of dams and other hydraulic structures in our river valley projects is necessary in the interest of safety of the structures and for effecting economies in their design, construction and operation. The example of Bhakra Dam has clearly established the utility value of instrumentation.

A variety of instruments have been designed abroad to take the various measurements for structural behaviour study. However, non-availability of these instruments within the country presents a big hurdle in the effective implementation of measurement programmes on our hydraulic structures. There is, therefore, an urgent need for the indigenous manufacture of some of these instruments. A criterion has been suggested whereby some instruments may be accorded a high priority for indigenous manufacture by the industry and government. An assessment of future demand of these instruments up to the end of the Fourth Five-Year Plan will be available after the Government of India's Committee on Instrumentation submit their report to the Government.

Acknowledgement

The author is grateful to Shri C. L. Handa, Member (D&R) and Shri Y. K. Murthy, Director (Dams), CW & PC, for their constant encouragement and permission to present this paper before this Conference.

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APPENDIX

Indian Dams Instrumented

	Height (ft)	State
Concrete		
Bhakra	740	Punjab
Rihand	304	U.P.
Koyna	338	Maharashtra
Stone Masonry		
*Linganamakki	199	Mysore
Gandhi Sagar	212	M.P.
Nagarjunasagar	370	A.P.
Parambikulam	180	Madras
*Hirakud	195	Orissa
Tungabhadra	162	Mysore
Malampuzha	125	Kerala
Walayar	86	Kerala
Earth		
Linganamakki*	199	Mysore
Sampna	76	M.P.
Datla Tank	87.5	M.P.
Nanak Sagar	54	U.P.
Jirgo	90	U.P.
Kota barrage	120	Rajasthan
Dantiwada	120	Gujarat
Hathmati	—	Gujarat
Meshwa	—	Gujarat
Ukai	228	Gujarat
Hirakud*	195	Orissa
Bor	119	Maharashtra
Nalganga	98	Maharashtra
Girna	172	Maharashtra
Ghod	—	Maharashtra
Gangapur	123	Maharashtra
Buggavagu	100	A.P.
Other Structures		
R.C.C. Dact (Sharavathi)	20′ high & 10,894′ long	Mysore
Head race tunnel (Koyna)	21′ dia. & 12,000′ long	Maharashtra
Pressure shaft (Koyna)	10′ dia. & 2,066′ long	Maharashtra
Motichar Weir		Gujarat
Pasuvemila horse-shoe (Nagarjunasagar)		A.P.
Durgapur Barrage		West Bengal

*Stone masonry-cum-earth dams.

Instrumentation for Vibration Studies

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The Earthquake School is actively pursuing research on instrumentation connected with vibration studies and recording the response of engineering structures to earthquakes. For measurements, on prototype or models, of motions like displacement, velocity, acceleration and strains, instruments have been designed and manufactured in the School. The most important contribution of the School has been made to the earthquake studies in the design of Structural Response Recorders, their manufacture at the School shops and their installation at suitable stations in the seismic zones. More stations are being built and the instrument further developed. This idea was presented at the World Conference on Earthquake Engineering earlier this year and has been appreciated. This programme has saved a large amount of foreign exchange that would have been necessary if more sophisticated instruments were imported. This instrument is an idealized engineering structure and will record the maximum acceleration that the prototype, that may be built in the region, will be subjected to during earthquakes.

For vibration measurements, invariably, electrical devices are used, the reason being quick changes of motion. The measuring system may be broadly divided into three categories:

(i) A device for converting mechanical motions into an electrical signal. This device is known as pick-ups.

(ii) An amplifier may be used to magnify this electrical signal.

(iii) A device to record actual motion. This may be known as recorders.

As far as pick-ups are concerned, extensive work has been done at the School. It is our contention that we should be able to make any type of vibration pick-up with materials indigenously available. We have designed and built pick-ups to measure displacement, velocity, acceleration and also to measure strains, pressures, loads etc. Brief description of the various equipment that have been manufactured at the School is given in various Annual Reports of the School. The pick-ups that have been manufactured at the School have not only been used in models but have been used for field tests as well. It is hoped that some industry would come forward to manufacture these pick-ups and we would be able to give them all technical advice that is needed. This would go a long way in saving foreign exchange as far as import of this item is concerned.

About amplifiers, we hope, that it will be possible to manufacture them in this country. Technical advice in connection with manufacture of amplifiers could be tendered by several organizations in this country which

are specializing in electronics. However, at present, the type of amplifier, needed for mechanical (low frequency) vibration measurements, are not made in the country.

Several organizations in the country manufacture oscilloscopes, galvanometers, etc. In addition it would be necessary to manufacture oscillographs. We can render technical advice for the manufacture of oscillographs. It will be possible to make oscillograph with indigenous materials.

Bonded wire resistant strain gauges which are extensively used for dynamic as well as static measurements are now made in India. The School has tendered technical advice in the manufacture of straingauges to a firm located in Roorkee.

In addition to vibration measurements, the School will be able to give technical advice in connection with the manufacture of instrument for static measurements like pressure, pick-ups, load cells etc.

In addition, we have also manufactured special type of vibration intensity recorders (Structural Response Recorders).

We hope, members of the industries would come forward to mass manufacture instruments for vibration studies. Almost all the requirements of vibration instruments in this country could be made with materials indigenously available and we will be able to offer technical advice in the manufacture of these instruments.

Indigenous Manufacture of Electronic Instruments

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One should feel proud and happy when the nation becomes completely self-reliant, whatever be the field. It is a matter of satisfaction that we have been able to achieve this in various items. To name few, we have radios, transistor radios, electrical accessories, cables, telephones, machine tools etc. But the problems confronting a venturesome small scale industrialist who ventures to manufacture specialized instruments are manifold. In the paragraphs to follow, practical difficulties experienced have been cited.

The basic problem is the nonavailability of the raw materials and components. Any electronic equipment, whatever be the field of application whether medical, chemical, industrial or automation etc. requires basic components like switches, band switches, relays, valves, resistors, condensers, transformers etc.

Valves and transistors (only certain specified types) are being manufactured in India by Bharat Electronics Ltd, Bangalore. Most of the time these are in such short supply that they are sold at a minimum of 4 times the prices advertized by the manufacturers or are not at all available. To cite an example valve EZ 80 is being sold in Bangalore at Rs 22 plus local tax at 10 per cent and UV 41 valve at Rs 20. The production of valves and transistors will have to be stepped up so as to meet the evergrowing demand or some alternative remedy must be provided. The impact of this price spiral on the small scale manufacturer is so much that it may force him to give up.

Band switches are being manufactured in India by various firms. Notable amongst them are the REMCO and SIRCO switches. Specialist equipment requires bandswitches that have to be fabricated to the desired specifications. To get this done, one has a very long wait anywhere between 6 and 36 months. This necessarily means that the small industrialist has to pay 25 per cent advance in the first instance and later on purchase his requirements for at least 24 months. This will result in the blockade of a sizable amount and the subsequent inconvenience to the small industrialist.

Relays are very necessary in the fabrication of all types of instruments. At the present, Indian Telephone Industries Ltd, Bangalore is the only firm manufacturing this item. Here again to get one's specialized requirements one has to wait for months which results in the capital amount getting blocked. As the imports have been curtailed this amounts to nonavailability. Here again some alternate method must be found.

Carbon resistors are essential everywhere in the circuit. Precise instrumentation requires the utilization of 1, 2 and 5 per cent tolerance resistors of assorted values and also of different wattages. This is being

manufactured in India by M/s Rescon Manufacturing Co., Poona who are so much overburdened by the demand that one cannot expect delivery of their requirements earlier than 36 months. The Electronics division of the Atomic Energy Establishment Trombay have also developed these resistors and their delivery schedule is from 6 to 12 months. These values of resistors required are not available even in some of the major cities in our country.

Transformers pose yet another problem. For instrumentation, this has to be specially wound. As is well known, the transformer is the heart of any equipment. There are a good number of transformers manufacturers in our country who can readily supply the power transformers, I.F. transformers, output transformers, and vibrator transformers required for the radio industry. Here again, a small industrialist fabricating or developing a specialized instrument whose demand is very limited cannot depend on ready compliance of his requirements. In some cases, depending on the availability of the stampings, farmer & coil size, one may have to vary other parameters in one's design.

Electrolytic condensers, Paper condensers and Mica condensers are being widely manufactured in our country. In this case, the demand is being met adequately. However, electrolytic condensers of high value of the order of 500 microfarads rated at 500 to 700 volts are not available. This has resulted in many electronic flash units in the country lying idle with their owners. The price of the imported ones which are rare perhaps exceeds the cost of the flash unit itself! Paper condensers of value more than 1 to 2 microfarads rated at 500 volts are not available. Sometimes condensers of value 4 or 8 microfarads become necessary.

Panel meters of various ratings for measurement of voltage and current are being manufactured by a number of large well-known firms. To name some, we have B.P.L. Automatic Electric, Kaycee, Ruttonsha-Simpson, Gaumont-Kalee and others. The delivery schedule is not so long and one can procure one's requirements in 6 to 10 weeks.

Metal rectifiers of various ratings are also being manufactured by some. Mention may be made of Kaycee, Semikron & Elvoc.

Wirewound resistors of assorted values and higher wattage capacity are also being manufactured. In this category we can consider carbon and high wattage wirewound potentiometers. Well known in this category are the RVM resistors.

Test equipment like C.R.O., vacuum tube voltmeter, signal tracer, LCR bridges, oscillators are being widely manufactured. Amongst the manufacturers are Philips, Ruttonsha-Simpson, B.P.L., Bharat Electronics and I.T.I.

Assorted components like knobs, groupboards, lugstrips, valve bases, fuse holders, jewel lamp holders etc. are being manufactured in our country. The quality of the items manufactured is quite good and the finish of the product quite impressive. The quantity manufactured meets the demand of the nation.

Summarizing, the success of the instrumentation industry depends to a very large extent on the availability of the various components mentioned at short notice. Once we are able to achieve this then we can develop instrumentation industry rapidly. So our primary aim must be to boost

up the production of components or alternately allow the import of some of the specialized components. Secondly, standardization of the products manufactured is an essential requisite. In this context the Indian Standards Institution has already done a great job. The success of this aspect depends on the cooperation it receives from the manufacturers. Thirdly, as far as possible, full utilization be made use of the technical potential availability in the country. In some cases foreign collaboration becomes necessary to achieve positive results in a short time. Fourthly, there must be closer coordination between the small industrialist and the research organizations. Fifthly, there must be a clear-cut policy in regard to the research organization providing the technical know-how after they develop certain gadgets to certain selected small industrialists of standing who are genuinely capable of producing the same. In this context the development of Japan is an ideal example. It is heartening that the Central Electronics Engineering Research Institute, Pilani and the National Physical Laboratory, New Delhi are amongst some research organizations adopting this method. Some of the big industries which have taken up the manufacture of some of these items which ought to be manufactured under a small unit have failed both in supplying the demand and give service after sales facilities. It is natural that they cannot afford to have special staff for the small requirements. They will do well to sub-contract the item that they have developed to a smaller unit on some understanding. This naturally achieves a two-fold result namely production is kept up and the bigger unit gets credit and payment for its investment.

Referring to the field of medical electronic instrumentation, there is very wide scope for development. This results in import substitution to a very large extent which results in considerable saving in foreign exchange. Once the equipment manufactured in the country attains certain standard, export possibilities could be considered. One must however note that the first step is to provide an opportunity to the venturesome to develop the equipment simultaneously banning the import of the same. In the early stages the quality and performance will not be so good. The reasons for this drawback mainly result from the fact that components are procured from various sources and also that the sub-assemblies are done by subcontract. But once the firm settles down the standardization aspect can be considered. Another important aspect is the time wasted over preliminaries in regard to inspection etc. In this context again the inspection authority must use its discretory powers in regard to certain minor mechanical alterations and prevent undue delay. This certainly does not imply that defects should be overlooked but certainly means that once the performance and safety aspects are complied with there need not be any rigidity. Perhaps this aspect has deterred many a small venturesome person to undertake manu facture. Once this is overcome, many will come forward. This is -of particular importance in the present context and also in regard to development of equipment for defence. As already pointed out standardization follows after production. One recollects the dogma attached to Japanese goods some years back when it was in the development phase. In some measure the same applies to Punjab in our country which is quite advanced in small industry. Today, we see that the quality of goods produced in both cases are as good as any elsewhere.

This note briefly deals on some of the problems that confronts a venturesome small industrialist. One can feel optimistic in spite of some of the drawbacks, as most of them can be overcome in the course of time by sincere and sustained hard work.

APPENDIX 1

Equipment that could be taken up for development by research laboratories and consequent manufacture by small industrialists

1. Recording Instruments
   (a) Electroencephallograph
   (b) Electrocardiograph
   (c) Electromyograph
   (d) Electroretinograph
   (e) Impedance plethysmograph
   (f) Multipurpose recorders to record physiological entities like pressure, temperature etc.
2. Stimulators
   (a) Nerve & Muscle stimulators
   (b) Convulsive stimulators
   (c) Cortical stimulators
   (d) Defibrillators, Internal & External
   (e) Pacemakers, Internal & External
3. Diathermy
   (a) Short wave & long wave Diathermy for Surgery & Physiotherapy
4. Ultrasonics
   (a) Ultrasonic cleaners
   (b) Ultrasonic therapy units
   (c) Ultrasonic surgery units
5. Audiometers
6. Hearing Aids
7. Endoscope-cautery units
8. Spectrophotometers
9. *p*H meters
10. Visual & Photoelectric colorimeters
11. Incubators
12. Ovens
13. Heart rate meters
14. Sphygmomanometers
15. Telethermometers
16. X-ray units, Diagnostic & Therapeutic
17. Nuclear instruments :
   (a) Counters (b) Probes (c) Monitors (d) Spectrometers etc.
18. Electronic Test Equipment
   (a) CRO (b) VTVM (c) LRC bridges (d) Valve & transistor testers (e) LF oscillators for medical use (f) General purpose oscillator
19. Transducers

It should be noted that some of the items cited have already been developed and are marketed in the country.

APPENDIX 2

Name of some manufacturers in the country

	Manufacturer	*Items manufactured*
1.	Indian Telephone Industries Ltd, Bangalore-16	Electroconvulsive Therapy unit & Defibrillator
2.	Radio & Electrical Mfg Co., Bangalore-18	Electric massager
3.	Bharat Electronics Ltd, Bangalore-13	Audiometer, Hearing aids & Electrocardiograph
4.	J. N. Marshall & Co., Poona	Transistorized Electrocardiograph
5.	Elpra International, Poona	X-Ray equipment
6.	Escorts Ltd, Faridabad	X-Ray equipment
7.	Siemens Engng & Mfg Co. Ltd, Bombay-1	X-Ray equipment
8.	Philips India Ltd, Calcutta	Ultraviolet & Infrared lamps etc.
9.	Applied Electronics (P) Ltd, Bombay-8	Defibrillators, Pacemakers, Phorisis units, Telethermometers, E.C.T. units etc.
10.	Trombay Electronic Instruments, Bombay-74	Nuclear Instruments
11.	Toshniwal Instruments (P) Ltd, Indore	Medical stimulator, Phonsis unit etc.
12.	I.N.C.O., Ambala	Incubators, ovens, Physiology laboratory equipments etc.
13.	Associated Electronic Engineers, Bangalore-3	ECT units, Ionization apparatus, Defibrillator, Phorisis unit, Endoscope-cautery transformers, Stimulator etc.

Price: Rs 4.50 Sh. 9/- $ 1.50